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Biological Environment of Eastern Lancaster Sound and Western Baffin Bay: Components and Important Processes

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1.0 INTRODUCTION

Relative to other portions of the high Arctic, the eastern Lancaster Sound-western Baffin Bay area supports an abundance of marine mammals, seabirds and other forms of life. In recent years there have been two proposals for exploratory drilling in these waters--by Norlands Petroleums Ltd. and by Petro-Canada Exploration Inc. As a result of this interest by the oil industry, and the consequent need for assessments of potential effects of drilling on the ecosystem, extensive biological and other studies were conducted in the area in 1975-79. The 1978-79 work formed the northern portion of the Eastern Arctic Marine Environment Study (EAMES), and the 1975-76 work has been considered, retroactively, to be a part of EAMES.

1.1 Purpose of this Report

The EAMES studies have resulted in numerous technical reports describing the methods and results from the individual studies, and much of this material has been published or is in press in the open scientific literature. However, there has been no previous summary and interpretation of these results, and of the earlier literature, in any one document. The present report is designed to fill that need.

This document contains, in Section 2, a summary of present knowledge of the main groups of biota in the study area. These biota include marine mammals and birds, marine and anadromous fish, benthic invertebrates, ice biota and plankton. Relevant information about nutrients and the physical environment is also summarized. Section 2 includes some numerical details and some of the main results from the various studies done in 1975-79. However, the emphasis is on summarization and integration in a concise format. For substantiation and detailed information, the reader is referred to the original technical reports and published papers.

Sections 3, 4 and 5 summarize present knowledge of the main ecosystem processes in the study area. Section 3 deals with the distribution of various marine birds and mammals in different habitat types within the area. Section 4 discusses the diets of the main species and groups, and the food web in the area. Section 5 examines the roles of certain important physical factors, especially nutrient availability and ice conditions, in controlling the abundance and diversity of life, and the seasonal variations in numbers, distributions and life processes of marine plants and animals. These sections are based largely on work done during the EAMES studies, but some of the analyses and interpretations presented here are new and are not treated in the original reports and papers.

Section 6 summarizes the biological importance of the study area in relation to other areas.

1.2 Study Area

No single and rigorous definition of the study area has been used in this report. Because of the proposed locations of initial exploratory wells, most interest and studies have been centred in eastern Lancaster Sound (74°N lat.) and the portion of western Baffin Bay just to the east and south of Lancaster Sound. However, this area is a very open system and it cannot be considered in isolation. Many of the main physical and biological processes that occur there, including currents, patterns of ice breakup, and movements of most of the major species of marine mammals and all seabirds, actually occur on a substantially larger scale.

In recognition of these large-scale phenomena, some studies done under EAMES in 1978-79 have extended north to the northernmost part of Baffin Bay (77°N) and some have extended south beyond Clyde (70°30'N). Most work has been in the western half of Baffin Bay and in the eastern portions of adjacent channels (Jones Sound, Lancaster Sound, Pond Inlet and Eclipse Sound), but some surveys have extended east close to Greenland, and some have extended west to Navy Board Inlet and Admiralty Inlet. Most of the wide-ranging biological work has involved aerial surveys of marine birds and mammals or shipboard sampling of plankton. Ground- and ice-based studies have concentrated in the central part of the overall study area.

All of the 'Northern EAMES' studies are considered in this review, but primary attention is focused on eastern Lancaster Sound and western Baffin Bay from Coburg Island (76°N) south to Clyde (70°30'N; Fig. 1.1). Previous studies in this area are also considered in detail, and information from other parts of the Arctic is considered and referenced where relevant. When estimates of numbers or productivity are given, the area under consideration is specified.

1.3 Topics Emphasized

Waterbirds and marine mammals are the organisms most likely to be affected by offshore hydrocarbon development in the study area. There are no commercial fisheries in the area, and subsistence fishing in marine areas is limited. However, fish--especially the arctic cod, *Boreogadus saida*--are important food organisms for many of the main species of seabirds and marine mammals. Birds and mammals that feed on arctic cod are indirectly dependent on the zooplankton and ice-associated amphipods that cod consume, and some birds and mammals also rely directly on zooplankton, ice biota, or benthic organisms for at least part of their diet. All of these groups are ultimately dependent on primary production by plants (phytoplankton, benthic plants and ice algae), and on the physical factors that control the rate and seasonal timing of primary production (e.g. ice conditions, water depth, mechanisms of nutrient replenishment). Furthermore, marine birds and mammals are influenced directly by some physical factors such as ice, water depth, and coastal morphology.

All of the aforementioned topics are discussed in this report, but the level of detail varies. Waterbirds, marine mammals and a few of their key food species are considered to be of much intrinsic importance, and therefore each species is discussed in some detail. Other groups of organisms and topics mentioned above are considered to be of interest primarily because of their importance, direct or indirect, to marine birds and mammals. These groups are treated in a more general way.

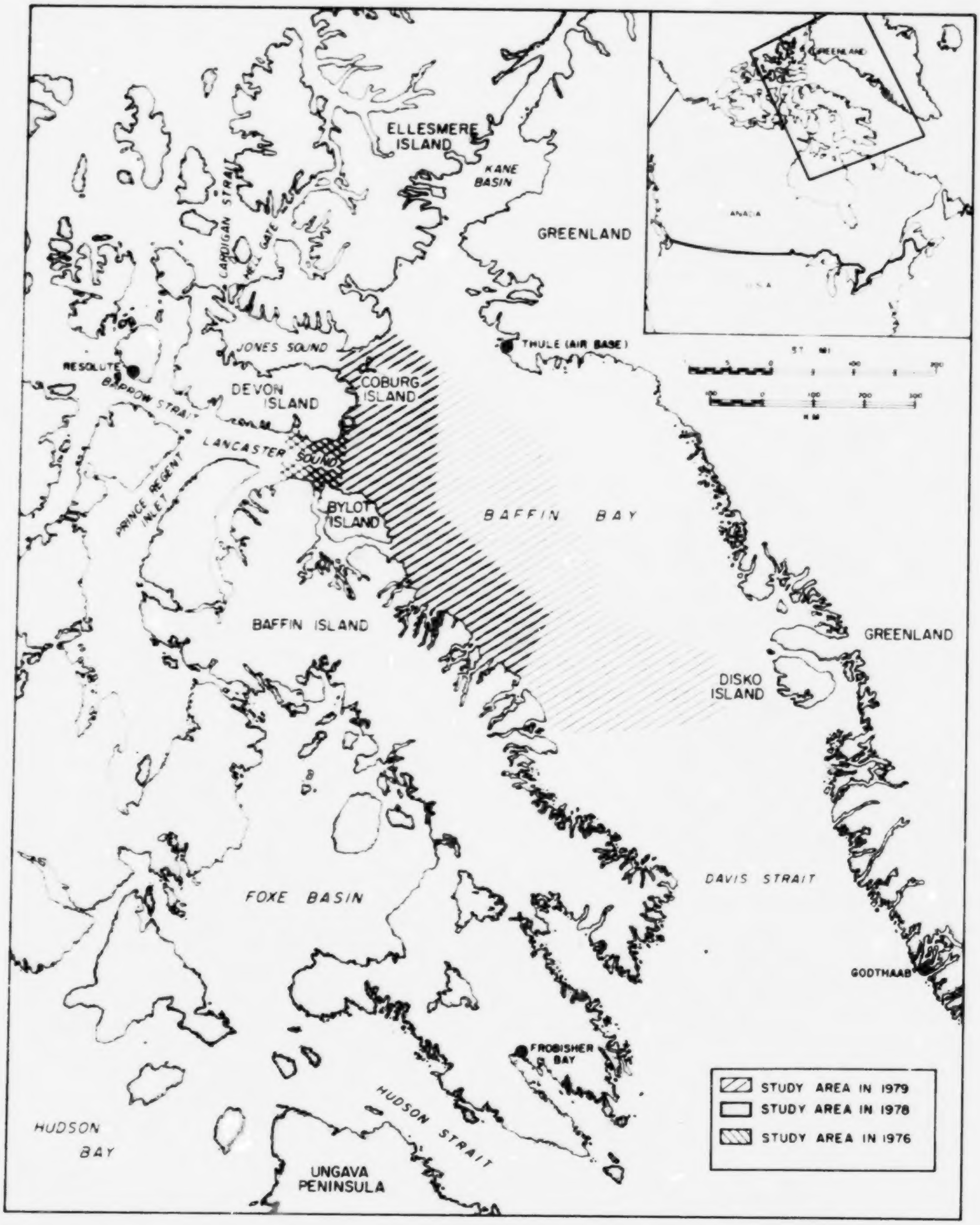

ELLESMERE ISLAND
KANE BASIN
GREENLAND
CARDIGAN STRAIT
HELL GATE
JONES SOUND
THULE (AIR BASE)
RESOLUTE
BARROW STRAIT
DEVON ISLAND
COBURG ISLAND
LANCASTER SOUND
PRINCE REGENT INLET
BYLOT ISLAND
BAFFIN BAY
BAFFIN ISLAND
GREENLAND
DISKO ISLAND
FOXE BASIN
DAVIS STRAIT
GODTHAAB
FROBISHER BAY
HUDSON STRAIT
HUDSON BAY
UNGAVA PENINSULA
ST MI
KM
GREENLAND
CANADA
U.S.A.
STUDY AREA IN 1979
STUDY AREA IN 1978
STUDY AREA IN 1976

FIG. 1.1. Map of the eastern Arctic showing areas of studies reviewed in this report.

2.0 ENVIRONMENTAL COMPONENTS

This chapter describes the marine environment of eastern Lancaster Sound and western Baffin Bay. The physical oceanographic regime, plankton, benthos, fish, seabird and marine mammal communities are identified, and discussed within this regional context. Geographical and seasonal variations are also discussed. These components are strongly interrelated and these interrelationships are identified and described in subsequent chapters.

2.1 The Physical Environment

2.1.1 Physical Oceanography

An extensive physical oceanographic field program was carried out during the periods July 1978 to October 1978 and July 1979 to October 1979 from the charter vessel MV *Theron* by Arctic Sciences Ltd. The overall objective was to provide a data base for a description of the mean circulation patterns of oceanic waters. The work included the first direct measurements of currents ever made in many parts of the study area. The following is a brief summary of the water properties and circulation patterns in the study area and has been taken from the results of these physical studies (Fissel *et al*. 1981).

2.1.1.1 Water Properties

The horizontal and vertical distribution of water properties (temperature, salinity and density) have been well defined in western Baffin Bay and Lancaster Sound. The waters can be divided into three vertical layers (Muench 1971):

(a) The Arctic Water, defined by low temperatures (0°C to -1.8°C) and low salinities (<31 °/oo to about 34 °/oo). This generally extends to depths of 200 to 300 m in Baffin Bay and Lancaster Sound.

(b) The Atlantic Water, defined by warmer temperatures (0°C to > 2°C) and higher salinities (34.2 °/oo to 34.5 °/oo). This generally extends from the bottom of the Arctic Water layer to depths of 600-700 m in Lancaster Sound and 1200-1300 m in northern Baffin Bay.
(c) The Deep Water, defined by low temperatures (0°C to 0.4°C) and nearly uniform salinities (34.48 °/oo). This layer extends from the bottom of the Atlantic Water in Baffin Bay to the seabed.

Additional data gathered by Fissel *et al*. (1981) indicate, however, that the stratification of the water in both the upper 75 m of the water column, and at the interface of the Arctic Water and Atlantic Water layers, is more complex than previously described. The upper zone of the Arctic Water layer is subject to large spatial and temporal variations due to the effect of surface processes such as solar heating, wind mixing and ice melt. The result of these processes is the production of a highly variable surface layer overlying the uniformly cold bulk of the Arctic Water layer. In 1978 and 1979, observed temperatures in the upper zone ranged from -1.8°C to 3°C or more, and salinities ranged from 20.0°/oo to 32.5°/oo. The uniform wind-mixed portion of the upper zone is variable in depth, ranging from 0 m (in the case of a pycnocline extending to the surface) to as much as 80 m. The mean depth was 13.5 ± 12 m. Offshore, the upper zone is usually well-mixed and appears to deepen throughout the open water season under wind influence. After mixing has occurred, there is little alteration of the density stratification, which is controlled primarily by salinity distribution.

The transition zone between the cold Arctic Water layer and the warmer, more saline Atlantic Water layer consists of numerous sublayers of relatively uniform temperature with large vertical temperature gradients occurring at sub-layer boundaries. The thickness of the sub-layers typically ranges from six to 30 m and temperature differences between sub-layers are as large as 0.5°C.

2.1.1.2 Surface and Near-surface Circulation Patterns

Figure 2.1.1 shows the major features of the surface and near-surface circulation in Lancaster Sound and Baffin Bay. The flow vectors are scaled according to the average of the observations for that location, although in most locations the magnitude of the current may vary by a factor of two or more about the mean. The circulation shown is not an exhaustive compilation of all possible circulation features, but a summary of the most dominant flow patterns.

The width of the nearshore zone in Figure 2.1.1 is somewhat arbitrary since it has been designed by observations at only three nearshore sites (Fissel et al. 1981). There are significant differences between circulation patterns in nearshore waters and those in offshore waters. In nearshore waters, circulation patterns are determined primarily by strong flows in adjacent offshore zones. However, several features of the coastline may also influence this circulation. These include local winds, especially along glacial valleys, tidal motions and freshwater input.

The circulation of the Arctic Water layer in western Baffin Bay is dominated by the Baffin Current. Originating primarily with Arctic Ocean water flowing into northern Baffin Bay through Smith Sound, Jones Sound and Lancaster Sound, the Baffin Current flows southeastward along the western side of Baffin Bay into Davis Strait. The current is stronger near the coast than in the middle of the bay. Though the net flow is southeastward, the path of the Baffin Current is characterized by a number of perturbations, some of which are transient in nature while others appear to be more or less permanent features. Perhaps the most striking of these is the intense but relatively narrow intrusive flow into eastern Lancaster Sound. The major circulation features of the study area are summarized below.

Off the entrance to Jones Sound, the circulation is dominated by a southeasterly outflow from the sound into Baffin Bay through Lady Ann Strait. The near-surface coastal flow off northeast Devon Island reaches speeds of up to 60 cm/s. Farther offshore, the currents are variable as to direction, with net flow to the southwest of about 10 cm/s near the surface. Farther south, the current stengthens to a strong flow about 25 km wide centred 20 to 25 km east of Philpots Island. The surface flow during summer is about 40 cm/s but occasionally reaches 60 cm/s. The current speeds reduce with depth, to about five cm/s at 250 m depth. Flow reversals can occur near the inshore edge of the current off Philpots Island. The offshore edge of the current in the same area was characterized by a large-scale meander in

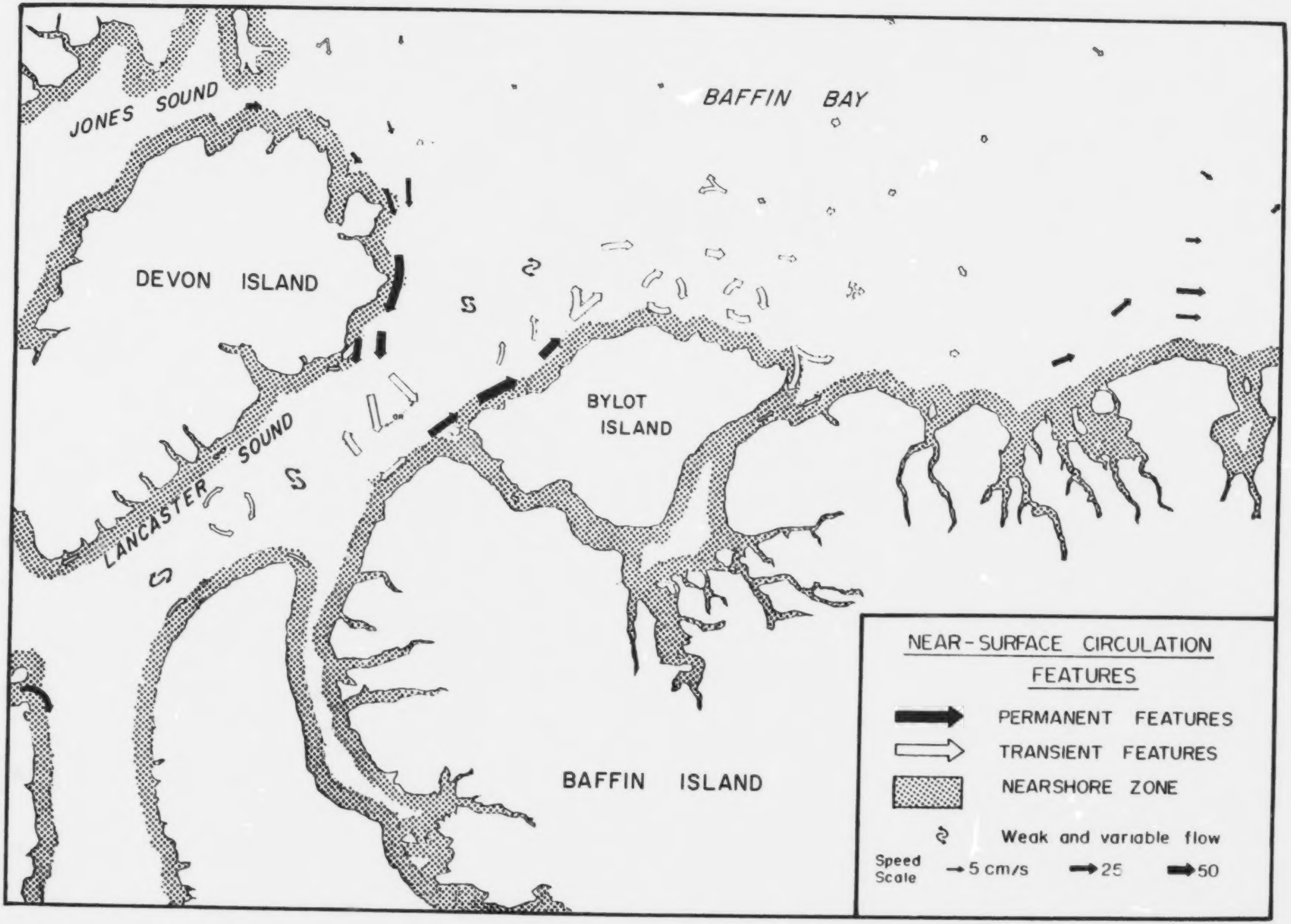

JONES SOUND
BAFFIN BAY
DEVON ISLAND
LANCASTER SOUND
BYLOT ISLAND
BAFFIN ISLAND
NEAR-SURFACE CIRCULATION FEATURES
PERMANENT FEATURES
TRANSIENT FEATURES
NEARSHORE ZONE
Weak and variable flow
Speed Scale
5 cm/s
25
50

FIG. 2.1.1 A schematic representation of the major near-surface circulation features in Lancaster Sound and western Baffin Bay. Adapted from Fissel _et al._ (1981).

1979. Southeast of Philpots Island, the flow turns southwest, converging and intensifying just east of Cape Sherard. Speeds up to 100 cm/s are achieved as the main core of the current rounds the cape some 20 km offshore.

The circulation of eastern Lancaster Sound is dominated by the flow of water from east of Devon Island intruding into the sound on its northern side. This water crosses the sound about 35 to 75 km from the eastern boundary and exits again into Baffin Bay along the northwest coast of Bylot Island, with a minor outflow south through Navy Board Inlet. The velocities associated with the intrusive current are generally strong near the surface and decrease with depth: typical velocities near the surface are 75 cm/s but only 14 cm/s at 500 m depth. The current may extend to the bottom of eastern Lancaster Sound. This intrusive current is a permanent feature of the summer circulation of eastern Lancaster Sound.

Important spatial and temporal variations occur in the intrusive current. The current has two modes of cross-sound spatial patterns, characterized by either southeastward movement towards northwest Bylot Island or south to southwestward flow towards the Borden Peninsula. The intrusive current alternates between the two modes, typically persisting in either mode for a period of several days. The flow off the Borden Peninsula is characterized by complex circulation features, apparently a result of the intrusive current meeting the outflow of Arctic Water passing through Lancaster Sound from the west.

The width of the intrusive current appears to increase in the course of its flow through the sound. On the northern side, its width may be as small as 10 km, but as the current crosses the sound the width increases to 15-30 km. Upon moving out of the sound, even greater widths can occur, presumably due to the combined influence of the intrusive current and the flow from western Lancaster Sound. The intrusive currents are associated with oceanic fronts. These fronts persist throughout the summer coincident with the presence of the intrusive current. Increased upward movement of nutrients may be characteristic of the fronts, resulting in enhanced biological productivity.

The circulation east of the entrance to Lancaster Sound is characterized by weak disordered flows with speeds on the order of 10-20 cm/s. Because the flow is extremely irregular, the net movement of the surface waters is small and appears to be directed to the south and east. Typical flow speeds are generally reduced to about eight cm/s between 250 and 750 m depth, and the direction is steadier and tends to net westerly movements.

The strong easterly flow along the north coast of Bylot Island usually becomes detached from the coast at Cape Liverpool, varying at that point from southeasterly to northeasterly, with the most common direction being easterly. Farther south, the current flows southeast, parallel to the east coast of Bylot Island, but usually 30 to 50 km offshore. At the southern end of Bylot Island, the flow turns westward, towards the mouth of Pond Inlet. This turning may be due to the local bathymetric features.

The Baffin Current dominates the water movements of western Baffin Bay along the length of Baffin Island. The core of the current is located at the edge of the continental shelf and over the most steeply sloping portions of the continental slope. Near-surface velocities are about 30 cm/s in the core, occasionally reaching speeds 60 cm/s. Farther offshore, velocities decrease, to about 10 cm/s, at the outer edge of the continental slope.

The circulation is highly variable in western and central Lancaster Sound. The net flow through the sound is eastward, but the current varies to location. At times, easterly flows are confined to the south side, while on other occasions such movements may occur in mid-channel. The most permanent feature of the circulation appears to be an intense (60 cm/s) southeastward coastal current flowing past Prince Leopold Island, associated with a cyclonic intrusive current flowing into and out of northern Prince Regent Inlet. A similar intrusive current pattern may be present at the mouth of Admiralty Inlet. Eddies are occasionally present in the middle of Lancaster Sound.

The net flow through the Navy Board Inlet-Eclipse Sound-Pond Inlet system is south and east, from Lancaster Sound to Baffin Bay, although there may be some local westerly or north-south flows in Eclipse Sound. Typical near-surface flow speeds are 20-30 cm/s. However, the southward flow into Navy Board Inlet appears to constitute only a small fraction of the total outflow from eastern Lancaster Sound.

2.1.2 Sea-ice Distribution and Movement

The following account is summarized from Marko (1982).

Ice conditions in Baffin Bay and Lancaster Sound can best be discussed as separate entities. In winter, the ice cover in Baffin Bay consists primarily of first year ice. Coverage is usually total (10/10), except in the North Water and in the southeast where open water extends northward along the west Greenland coast to about 71°N. Break-up of this winter ice begins in April as the North Water and the open water zone along west Greenland expand to the south and north, respectively. By July, pack ice in Baffin Bay is generally confined to an area bounded by 67°N and 76°N, and 60°W and 70°W. This ice typically dissipates by September, although incomplete clearance is not uncommon. A coastal landfast ice shelf often extends offshore from Baffin Island for 70 km or more; break-up and clearance of this ice usually occurs in July and August. Small amounts of ice enter Baffin Bay in August and September from Lancaster, Jones and Smith sounds, but new ice does not begin to form until September and October, beginning in the north.

In Lancaster Sound and Barrow Strait in winter, landfast ice extends across the channel. This ice is part of a large landfast ice sheet which covers most of the channels of the arctic archipelago during winter and spring. Coverage can be established as early as November or as late as April, and break-up usually begins in July. Large annual variations in the eastern extent of the ice sheet can occur (Fig. 2.1.2). The most common position of the ice edge lies adjacent to Prince Leopold Island, although it may vary from western Barrow Strait to eastern Lancaster Sound. Areas to the east of the ice edge are typically covered by pack ice in intermittent restricted motion, although an open water/thin ice zone is frequently adjacent to the edge. By late May or early June, much of this pack ice has cleared. Thus an ice edge in Barrow Strait usually leads to open conditions in June and early July throughout most of Parry Channel, whereas an easterly

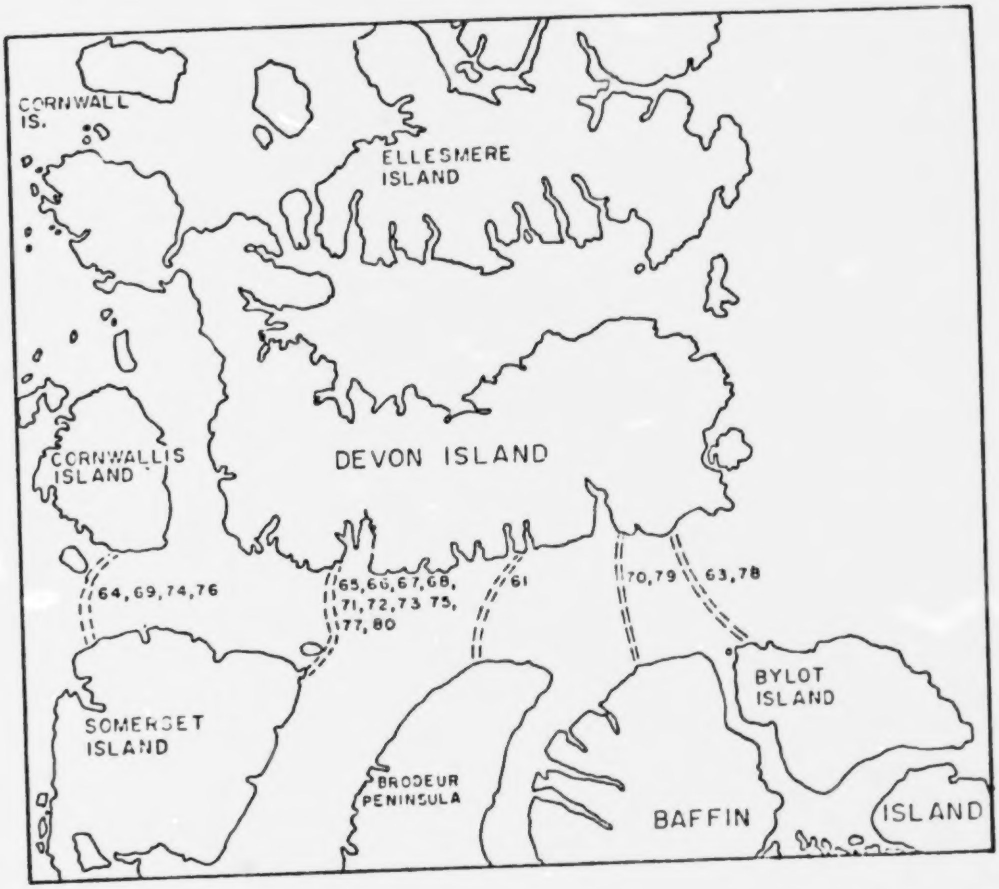

CORNWALL
IS.
ELLESMERE
ISLAND
CORNWALLIS
ISLAND
DEVON ISLAND
64,69,74,76
65,66,67,68,
71,72,73 75,
77,80
61
70,79
63,78
BYLOT
ISLAND
SOMERSET
ISLAND
BRODEUR
PENINSULA
BAFFIN
ISLAND

FIG. 2.1.2. Approximate annual positions of the stable winter landfast ice edge, 1961-1980. From Marko (1982).

ice edge produces near total coverage of the channel. Moreover, even after break-up of the fast ice, the resulting mass of broken pans generally ensures heavy ice conditions in the channel and western Baffin Bay for much of the remaining summer period. Similarly, there is much annual variation in the extent and break-up dates of coastal fast ice. Large shelves of landfast ice occur off east Devon Island adjacent to Philpots Island, and along north and east Bylot Island.

2.2 Nutrients

2.2.1 Types of Nutrients

Marine plants require many forms of inorganic salts, minerals, and vitamins for growth, metabolism and reproduction. These substances normally are dissolved in seawater and are absorbed directly by the plant. Dissolved minerals (e.g., copper, iron, and zinc) usually are required in only small quantities and are called micronutrients. Macronutrients are required in larger quantities; nine recognized elemental macronutrients are carbon (C), hydrogen (H), oxygen (O), nitrogen (N), silicon (Si), phosphorus (P), magnesium (Mg), potassium (K), and calcium (Ca) (Parsons et al. 1977). Of these, phosphorus, silicon and nitrogen are the most limiting nutrients to plant growth due to (1) their natural low concentrations in seawater and (2) decreased concentrations brought about by plant uptake and limited vertical mixing of the water column. Most plants cannot use elemental nitrogen, phosphorus or silicon and are dependent on the availability of inorganic salts of these elements (e.g., ammonia, nitrate, orthophosphate and silicate) (Raymont 1980). Thus, dissolved nitrogen may be present in appreciable quantities but low concentrations of ammonia and nitrate will still limit growth of most species.

Unlike freshwater systems, where phosphorus is the most limiting nutrient (Schindler et al. 1974), plant production in marine systems is primarily limited by nitrogen (Raymont 1980). Mid- or late summer measurements of usable forms of nitrogen in many arctic areas generally show only trace amounts to be present within the euphotic zone. This has been recorded in Frobisher Bay (Grainger 1975a), Jones Sound (Apollonio 1976b), Creswell Bay along Somerset Island (Sekerak et al. 1976a), Bridport Inlet along Melville Island (Buchanan et al. 1977), and Lancaster Sound and northwest Baffin Bay (Sekerak et al. 1979). However, depletion of nutrients is normally only evident within the euphotic zone -- the upper part of the water column where sufficient light penetrates for photosynthesis to proceed at a rate sufficient to maintain plants. The average depth of the euphotic zone in Lancaster Sound in 1976 was about 35 m (Sekerak et al. 1976b).

Substantial amounts of silicon are required only by certain types of phytoplankton (diatoms and silicoflagellates) for production of their siliceous frustules. Silicate is usually present in seawater in quantities such that other nutrients will be depleted before it becomes a limiting factor. However, in some circumstances, diatom blooms can deplete the surface waters of silicate and inhibit further growth (Parsons et al. 1977). Thomson et al. (1978) found unusually low silicate concentrations at one station in Brentford Bay (Boothia Peninsula) in September; they remarked that the low silicate concentration could have been inhibiting further growth. Since diatoms are an extremely important and abundant group of phytoplankton in arctic waters, the importance of silicate should not be overlooked.

2.2.2 Annual Cycle

Hydrographic and light regimes combine to severely limit plant production in arctic regions. For much of the year, nutrients are present in high concentrations, but low light levels preclude photosynthesis. Photosynthesis begins in late winter or spring. In spring and summer, ice melt, freshwater runoff and sunlight produce a relatively warm layer of low-salinity surface water. Due primarily to its low salinity (Fissel *et al.* 1981), this surface water is less dense than underlying waters and stability of the water column is generally maintained throughout the summer. Since little vertical mixing of water occurs, nutrient concentrations decrease as they are utilized by plants throughout the spring and summer. Concentrations of nitrate typically become depleted to such an extent that further primary production is severely limited. Figure 2.2.1 is an example of typical concentrations of nutrients in the arctic in early spring and late summer.

The general mechanism of annual renewal of nutrients in arctic surface waters is through a reduction of the stability of the water column in fall and winter (Coachman 1966; Dunbar 1970; Raymont 1980). Winter cooling, aided by the excretion of salts from ice and their entry into the water, increases the density of surface waters. In winter, density gradients in surface waters are usually very weak (Lake 1979), and at times isohaline and isothermal conditions exist. Such conditions promote vertical mixing of nutrient-rich deep waters with surface waters. In addition, mineralization (bacterial conversion of organic matter into inorganic compounds) proceeds throughout the year and contributes to the buildup of nutrients in the winter (Campbell 1980).

It should be noted that recycling of certain nutrients occurs in stable surface waters in the summer. For example, many types of zooplankton consume phytoplankton and excrete ammonia. Ammonia is one of the forms of nitrogen usable by plants. The relative importance of different nutrient regeneration mechanisms within arctic surface waters is not well known, but it is generally believed that annual winter renewal is of major importance.

2.2.3 Nutrients in Northwest Baffin Bay and Lancaster Sound

There has been considerable interest in the measurement of nutrients below the euphotic zone in the eastern arctic to obtain baseline data, to trace flow patterns from the Arctic Ocean, and to investigate nutrient budgets (Collin 1962; Franceschetti *et al.* 1964; Codispoti and Owens 1975; Jones and Coote 1980). Little research has been conducted concerning the relationship of nutrients in surface waters to primary production of the region. Irwin *et al.* (1978) measured nutrients and investigated primary production in Baffin Bay and adjacent inlets (including three stations in Lancaster Sound) but these data have not yet been interpreted. Measurements of surface nutrient concentrations obtained in the summer of 1978 (Sekerak *et al.* 1979) comprise the largest data set available for the study area.

Figures 2.2.2 and 2.2.3 illustrate sampling locations at which nutrient concentrations were routinely measured at 0, 5, 10, 15, 25 and 50 m depths. Sekerak *et al.* (1979) provide detailed information on sampling methods, laboratory analyses and results.

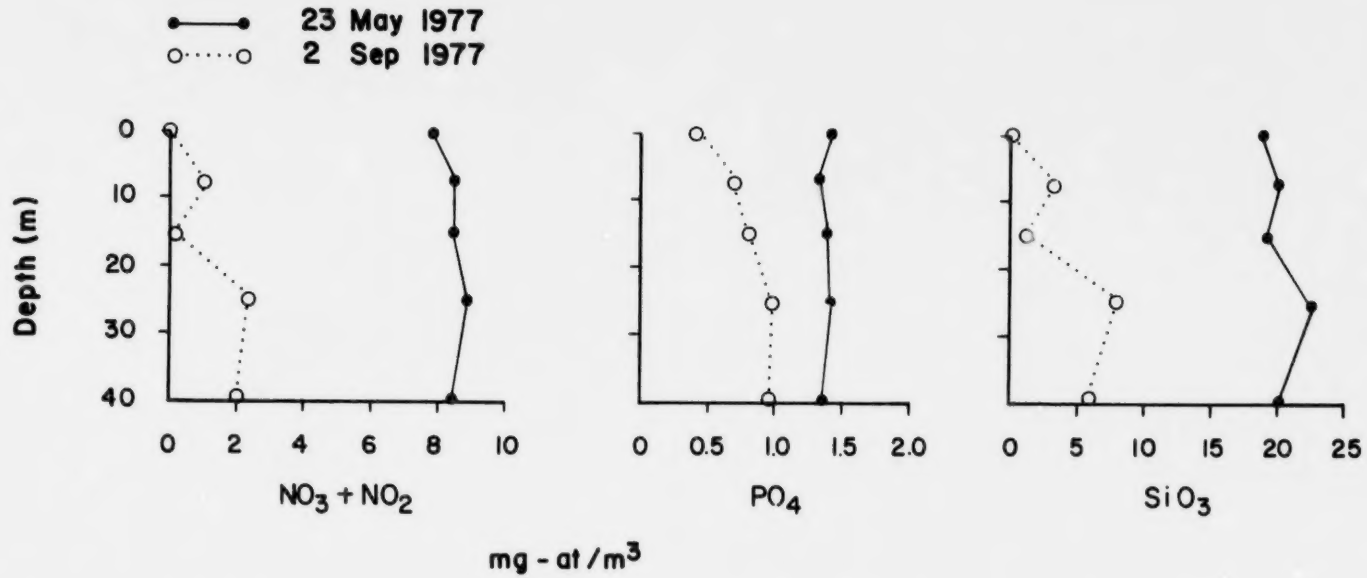


FIG. 2.2.1. Nutrient concentrations (mg-at/m^3) in Brentford Bay, Boothia Peninsula, in May and September 1977 (modified from Thomson et al. 1978).

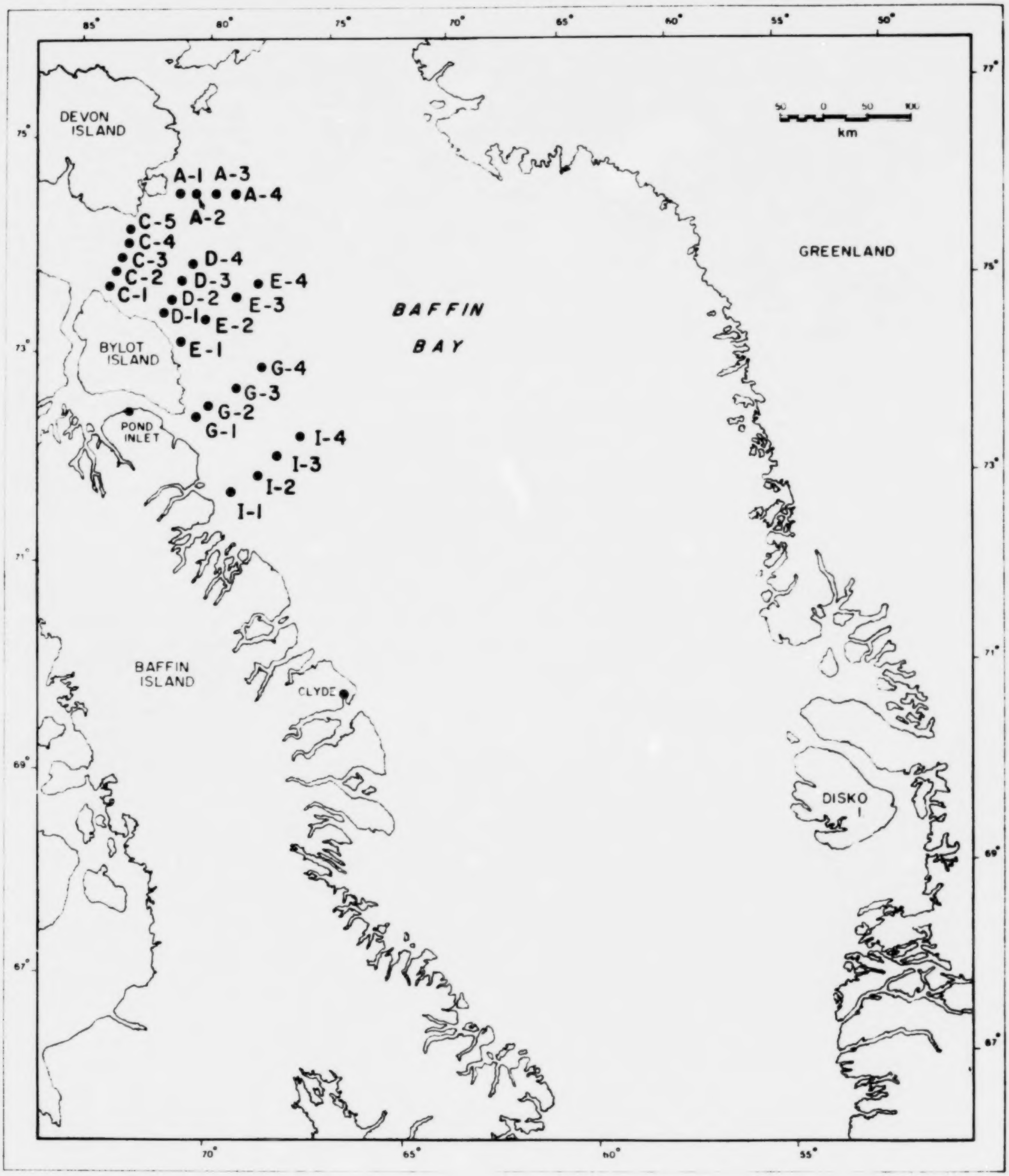

DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
BAFFIN BAY
GREENLAND
DISKO I
A-1
A-2
A-3
A-4
C-1
C-2
C-3
C-4
C-5
D-1
D-2
D-3
D-4
E-1
E-2
E-3
E-4
G-1
G-2
G-3
G-4
I-1
I-2
I-3
I-4
50 0 50 100
km
85°
80°
75°
70°
65°
60°
55°
50°
77°
75°
73°
71°
69°
67°

FIG. 2.2.2 Locations of stations sampled for nutrients during the periods 23 July-18 August, 19 August-17 September and 18 September-10 October 1978. All stations shown were sampled during each of the three periods.

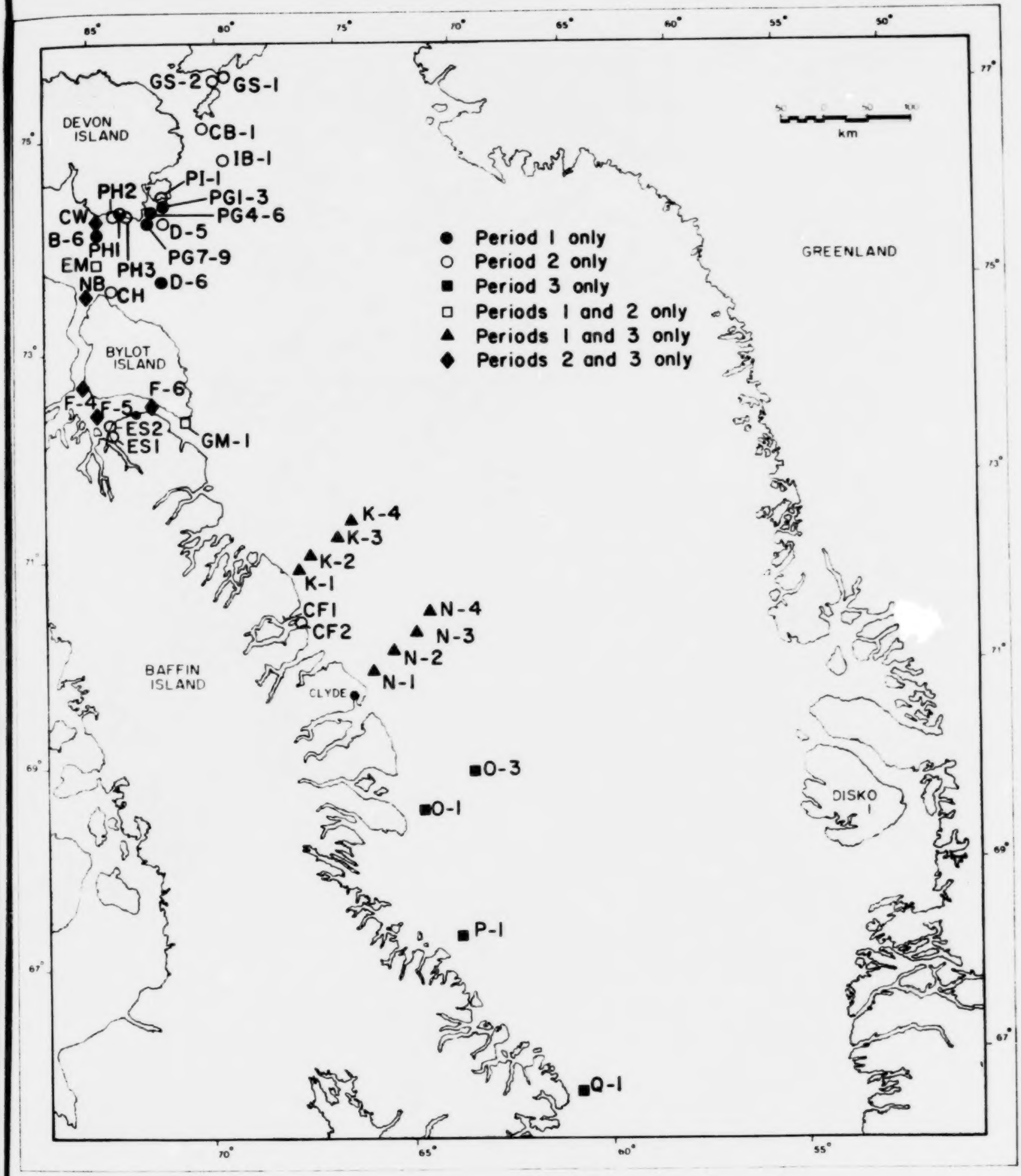

85°
80°
75°
70°
65°
60°
55°
50°
77°
75°
73°
71°
69°
67°
70°
65°
60°
55°
GS-2
GS-1
DEVON ISLAND
CB-1
IB-1
PI-1
PH2
PG1-3
CW
PG4-6
D-5
B-6
PH1
PG7-9
EM
PH3
D-6
NB
CH
BYLOT ISLAND
F-6
F-4
F-5
ES2
ES1
GM-1
K-4
K-3
K-2
K-1
CF1
CF2
N-4
N-3
N-2
N-1
BAFFIN ISLAND
CLYDE
O-3
O-1
P-1
Q-1
GREENLAND
DISKO I
km
● Period 1 only
○ Period 2 only
■ Period 3 only
□ Periods 1 and 2 only
▲ Periods 1 and 3 only
◆ Periods 2 and 3 only

FIG. 2.2.3 Locations of stations sampled for nutrients during the periods 23 July-18 August, 19 August-17 September and 18 September-10 October 1978.

Average nutrient concentrations in the upper 50 m of water at stations shown in Figure 2.2.2 decreased significantly from mid- to late summer but no significant change was evident from late summer to fall. Concentrations of nitrate + nitrite were particularly low (e.g., 0.1 to 0.2 mg-at N/m^3) in surface waters (i.e., 0, 5, 10, and 15 m) at some stations after mid-August. Such low concentrations, which are typical of arctic waters in late summer, are believed to severely limit primary production (Raymont 1980).

Concentrations of nitrate + nitrite (mean = 3.6 mg-at N/m^3 in the upper 50 m) during the initial phase of the study were substantially lower than those reported in other arctic regions earlier in the year. Therefore, primary production and depletion of nutrients were well underway in eastern Lancaster Sound and northwest Baffin Bay by mid-July 1978. Apollonio (1976b) found that maximum phytoplankton development in Jones Sound, as shown by chlorophyll concentrations, occurs in July when the melting ice sheet is still intact. Thus, the available data on nutrient concentrations in the study area are representative of the middle and later phases of the annual cycle of primary production.

Substantial variations were apparent in the concentrations of nutrients at stations along the transects, but few meaningful trends could be identified. Transects A, D, E, G, I and K (Figs. 2.2.2 and 2.2.3) were generally perpendicular to shorelines and nitrate + nitrite concentrations increased significantly with increasing distance from shore along the transects (Table 2.2.1). Mean nitrate + nitrite concentrations also differed significantly among transects during Period 1. Relatively high concentrations were found in east-central Lancaster Sound and in waters off northeast Bylot Island (Fig. 2.2.4). Low concentrations were found off northeastern Baffin Island and along the margins of eastern Lancaster Sound. This trend was not evident during the later two sampling periods.

Table 2.2.1. Mean and range (in parentheses) of depth-integrated nutrient concentrations (mg-at/m^2) in the upper 50 m of water occurring at stations 1 to 4 on oceanographic transects A, D, E, G, I and K. Station 1 is closest to shore on each transect (Figs. 2.2.2 and 2.2.3).

	Stations			
Nutrient	1	2	3	4
NO_3^-+NO_2^-	76.55 (4.50-251.6)	102.58 (7.9-300.4)	142.66 (52.90-249.70)	144.55 (65.3-288.0)
PO_4^{3-}	27.06 (13.10-48.20)	30.36 (13.50-54.60)	32.86 (16.70-53.2)	25.82 (13.1-42.3)
SiO_3^{2-}	365.4 (57.5-847.2)	438.1 (132.7-776.0)	411.2 (164.0-842.7)	356.8 (139.0-831.0)

Ice conditions indirectly affect nutrient concentrations in spring and early summer. McRoy and Goering (1974) found low nitrate concentrations near the ice front in the Bering Sea in April, and substantially higher

Station ->	C1		C2		C3		C4		C5		All C	
0° Depth (m) ->	390		247		249		~ 238		280		281 ± 63	
Layer ->	Ar	At	Ar	At	Ar	At	Ar	At	Ar	At	Ar	At
No. Samples ->	4	4	2	6	2	5	2	5	3	4	13	24
$NO_3 + NO_2$												
$\bar{x}$	10.59	10.39	8.06	12.18	7.01	11.62	7.98	11.44	6.55	9.47	8.32	11.16
SD	0.84	3.39	1.52	3.74	2.02	2.37	1.87	2.02	0.77	2.27	1.98	2.80
PO_4												
$\bar{x}$	1.06	0.89	0.90	1.02	0.81	0.99	0.86	1.01	0.79	0.88	0.90	0.96
SD	0.11	0.14	0.04	0.19	0.07	0.15	0.06	0.05	0.03	0.12	0.13	0.15
SiO_3												
$\bar{x}$	16.98	19.98	10.55	25.78	13.75	23.08	11.15	23.82	8.87	14.23	12.72	21.92
SD	3.22	6.76	0.92	10.98	5.16	6.17	3.61	5.78	3.85	4.73	4.42	7.97

Table 2.2.2. Mean nutrient concentrations (mg-at/m^3) in arctic and Atlantic water masses in eastern Lancaster Sound (transect C, 4-5 August 1978; from Sekerak et al. 1979). Waters above 100 m are not considered and 0°C is taken as the boundary between the two water masses. At = Atlantic.
Ar = Arctic

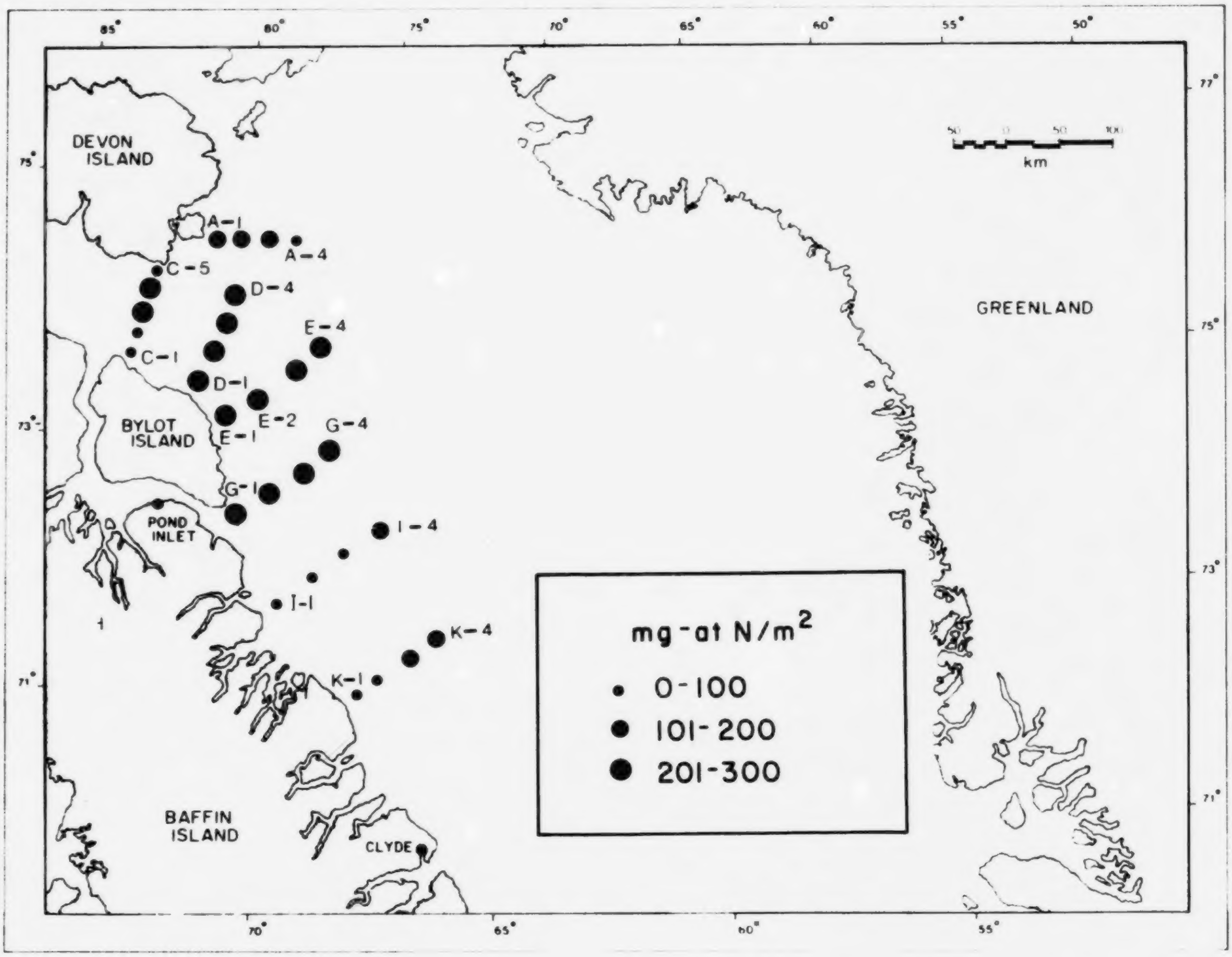

85°
80°
75°
70°
65°
60°
55°
50°
77°
75°
73°
71°
50 0 50 100
km
DEVON ISLAND
A-1
A-4
C-5
D-4
E-4
C-1
D-1
E-2
G-4
BYLOT ISLAND
E-1
G-1
POND INLET
I-4
I-1
K-4
K-1
BAFFIN ISLAND
CLYDE
GREENLAND
mg-at N/m²
● 0-100
● 101-200
● 201-300
70°
65°
60°
55°

FIG. 2.2.4 Depth-integrated nitrate + nitrite concentrations in the upper 50 m of water at stations along transects in eastern Lancaster Sound and western Baffin Bay during Period 1 (28 July-18 August 1979).

concentrations at stations tens or hundreds of kilometres to the south in open water and to the north under the ice. Planktonic production was highest near the ice front and accounted for the low nitrate concentrations. Similarly, during May and June 1979, nitrate concentrations in Pond Inlet were higher under fast ice 41 and 66 km away from the fast ice edge than at the ice edge itself (Cross 1980). Conversely, chlorophyll concentrations in the water were highest near the fast ice edge. Increased light penetration and the presence of a shallow mixed layer of water resulting from ice melt could induce early production near ice edges or ice fronts (McRoy and Goering 1974).

Ice break-up in the study area normally begins at the North Water and proceeds to the south. Although exact locations can vary substantially with year and date, fast ice edges occur across Jones Sound, Lancaster Sound (or Barrow Strait), and Pond Inlet. During spring, extensive areas of open water interspersed with pan ice exist in northwest Baffin Bay while areas to the west remain ice-covered. Light, salinity and, to a lesser extent, temperature regimes in spring and early summer vary substantially in different regions within the study area. Resultant variations in the timing of initiation of primary production in the water column could greatly alter the seasonal progression of nutrient concentrations in different areas. These differences would be most apparent from spring to about mid-summer.

Changes in the average vertical distributions of nitrogen, phosphorus and the nitrogen-phosphorus ratio with time are shown in Figure 2.2.5. In general, a low N:P ratio indicates high or previously high photosynthetic activity (Raymont 1980) whereas a localized high ratio (i.e. approaching 15:1) often indicates intrusion of deep water into the euphotic zone. The gradual depletion of nitrogen (and to a lesser extent of phosphorus) and the thickening of the depleted surface layer with time is evident (Fig. 2.2.5). This is a common feature of summer production in temperate and arctic seas and is associated with the gradual deepening of thermoclines and haloclines throughout the summer (Sverdrup et al. 1942; Raymont 1980). The relatively high N:P ratio at 50 m indicates that little photosynthetic activity was occurring at that depth. Sekerak et al. (1976b) found the summer euphotic zone to average about 35 m in depth in Lancaster Sound.

Nitrogen concentration appears to be the principal factor that changes the N:P ratios observed in the euphotic zone of the study area. This corresponds with the generally accepted view that nitrogen is the more limiting of the plant nutrients in marine waters.

2.2.4 Nutrients in Sea Ice

Since the time when underice biota were first recognized as an important component of arctic ecosystems, some information has been obtained on nutrients in sea ice and their utilization by ice flora (Apollonio 1961, 1965; Grainger 1977; Cross 1980). Nutrients in ice are incorporated from the water during freezing. Grainger (1977) gives a detailed account of the annual cycle of nitrate and phosphate in sea ice. In general, low concentrations of nutrients (<1 mg-at P/L and < 2 mg-at N/L) occur in most of the ice sheet; the nutrients in this ice become concentrated within the bottom few centimetres. In Frobisher Bay, Grainger found maximum quantities of phosphate and nitrate in the bottom 10 cm of ice (8.5 mg-at P/L and 15

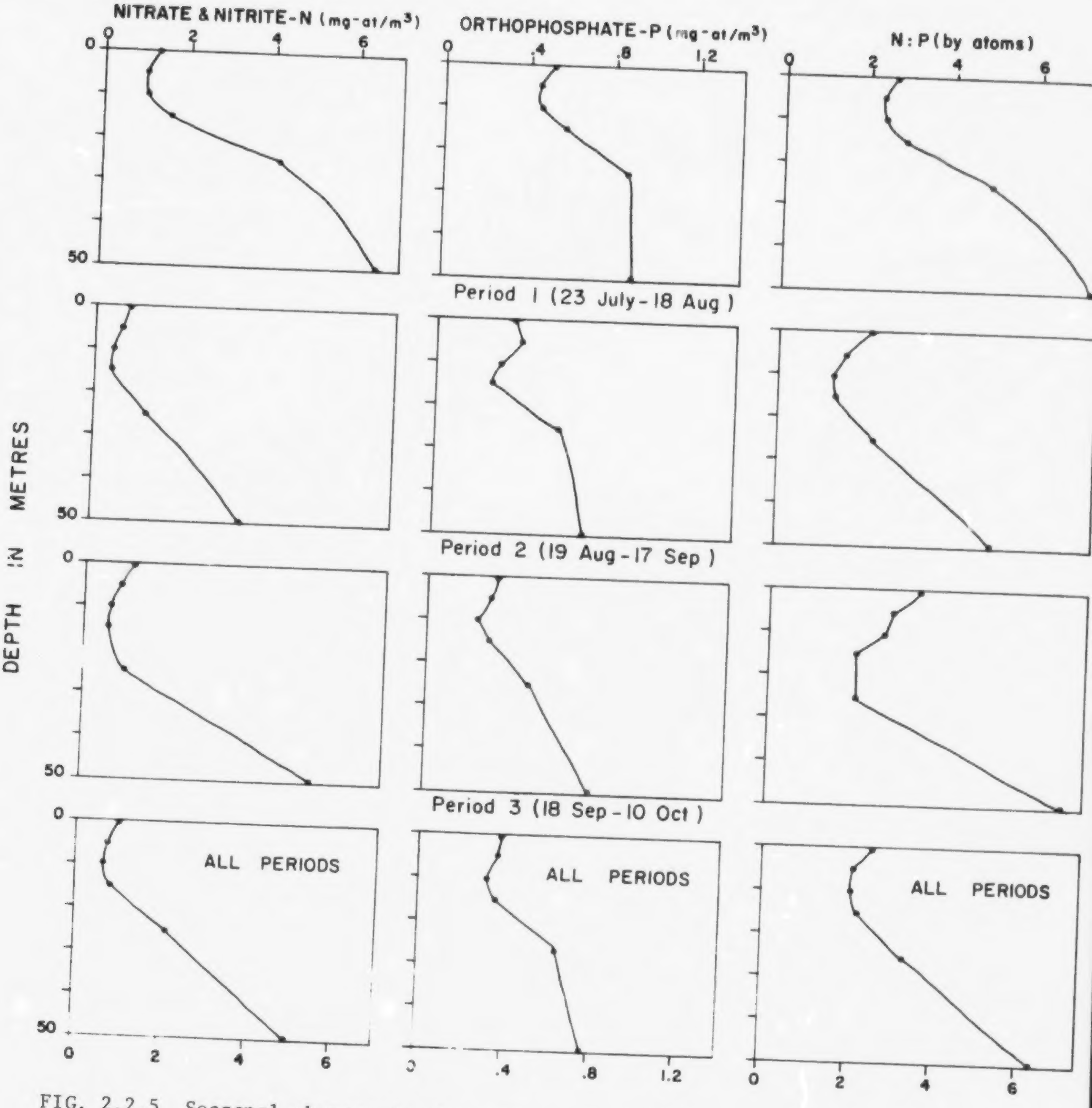


FIG. 2.2.5 Seasonal changes in the average vertical distribution of nitrogen, phosphorus and N:P ratio in the upper 50 m of water at oceanographic transects A, C, D, E, G and I shown in Figure 2.2.2. From Sekerak et al. (1979).

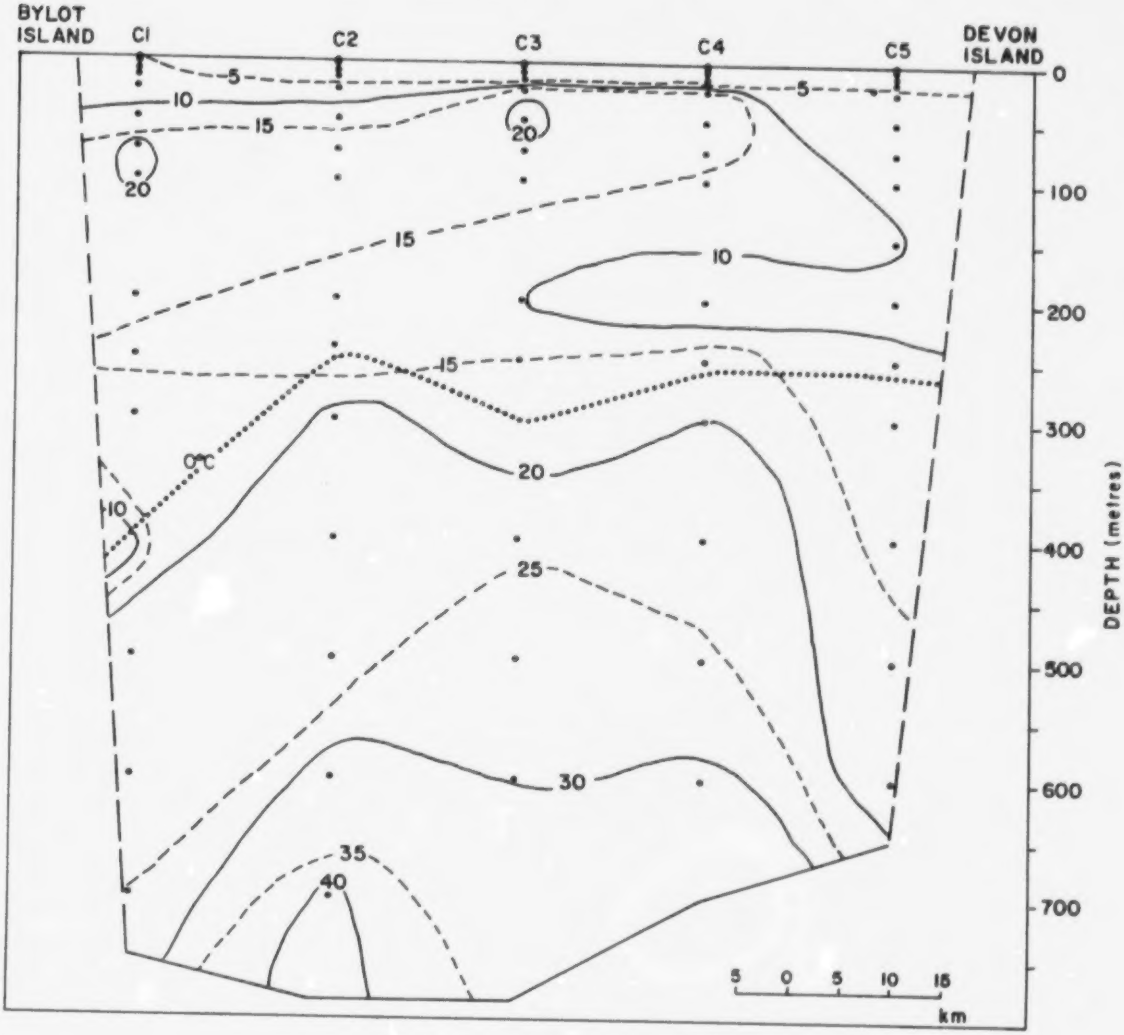


FIG. 2.2.6. Reactive silicate (mg-at Si/m^3) distribution in Lancaster Sounds along oceanographic transect C (31 July and 4-5 August, 1978). From Sekerak et al. (1979).

mg-at N/L). Cross (1980) found maximum quantities of 6 mg-at N/L, 1.7 mg-at P/L and 12 mg-at Si/L in the lower 20 cm of ice in Pond Inlet in May-June 1979.

Grainger (1977) tentatively concluded that phosphate and nitrate loss from the ice was proportionately less than chloride loss, and pointed out that Sverdrup et al. (1942) had suggested that changes in the relative composition of salts may accompany the formation and ageing of sea ice. This is of great significance, since the 'preferential' retention and concentration of nutrients near the bottom of the ice appear to permit increased primary production in that region.

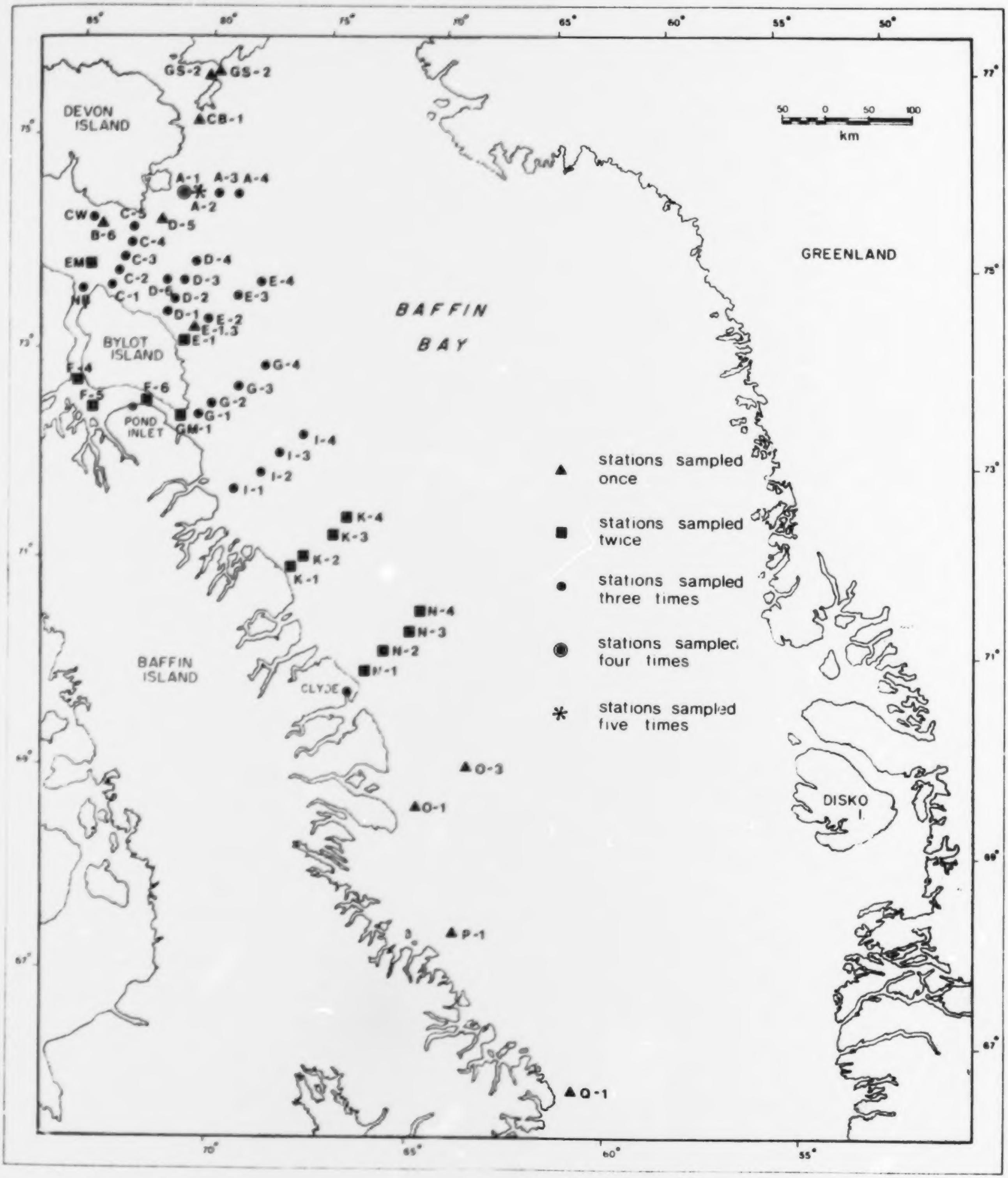
2.2.5 Nutrients in Deep Water

Nutrient concentrations in deep water were measured across the mouth of Lancaster Sound along transect C on 4-5 August 1978 by Sekerak et al. (1979); (Fig. 2.2.6). In this area there are two water masses, disregarding the upper mixed layer 50-100 m thick (Muench 1971; Fissel et al. 1981). The upper layer is cold, generally less than -1.0°C, and originates from the Arctic Ocean. The bottom layer is warmer, 0°C to >2°C, and is composed of water from the Atlantic Ocean partially mixed with the upper Arctic Ocean water in Baffin Bay. Although phosphate levels were relatively uniform, higher concentrations of nitrate + nitrite and especially silicate were found in the deeper Atlantic layer (Table 2.2.2).

Figure 2.2.6 illustrates the variable thickness of the arctic layer of water as defined by the 0°C isopleth and the corresponding variability of the 20 mg-at Si/m^3 isopleth. The relationship breaks down at Station C5 near Devon Island, where the strong intrusive current sweeps across the area. This current flows south along the eastern coast of Devon Island at least to Cape Warrender (Fissel et al. 1981). It could be composed of waters originating from Jones Sound, Smith Sound, or Baffin Bay, or a mixture of all three. Deep waters from these areas generally have lower concentrations of nutrients, especially silicate and phosphate, than waters from western Lancaster Sound (Jones and Coote 1980). Thus, dilution of nutrients along the north side of eastern Lancaster Sound, and to a lesser extent the south side, is explained by known flow patterns and variations of nutrient levels found in waters originating from different areas. Jones and Coote (1980) concluded that phosphate and silicate concentrations were useful indicators of flow patterns and water masses in some channels of the Canadian arctic and Arctic Ocean. Present data agree with this concept.

2.3 Plankton

Plants and animals that are carried along, more or less passively, in oceanic currents are collectively called plankton. The group is diverse and contains many species of unicellular plants (phytoplankton), invertebrates (zooplankton) and young stages of fish (ichthyoplankton). The depth distribution of viable phytoplankton is limited to the upper tens of metres, since light is required for photosynthesis. Zooplankton is also concentrated in surface waters, since the most abundant species are herbivorous and graze on phytoplankton. However, carnivores and scavengers are found at all depths. Ichthyoplankton is also most common in shallow waters where food is most available. Phytoplankton and zooplankton are the major primary and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55°
DEVON ISLAND
GS-2
GS-2
CB-1
A-1
A-3
A-4
A-2
CW
C-5
D-5
B-6
C-4
C-3
D-4
EM
C-2
D-3
E-4
C-1
D-6
D-2
E-3
NB
D-1
E-2
E-1.3
E-1
BYLOT ISLAND
G-4
F-4
F-6
G-3
F-5
G-2
G-1
POND INLET
GM-1
I-4
I-3
I-2
I-1
K-4
K-3
K-2
K-1
N-4
N-3
N-2
N-1
CLYDE
BAFFIN ISLAND
BAFFIN BAY
GREENLAND
DISKO I.
O-3
O-1
P-1
Q-1
50 0 50 100
km
▲ stations sampled once
■ stations sampled twice
● stations sampled three times
◉ stations sampled four times
* stations sampled five times

FIG. 2.3.1 Locations of offshore stations sampled for chlorophyll in eastern Lancaster Sound-western Baffin Bay, 23 July to 10 October 1978.

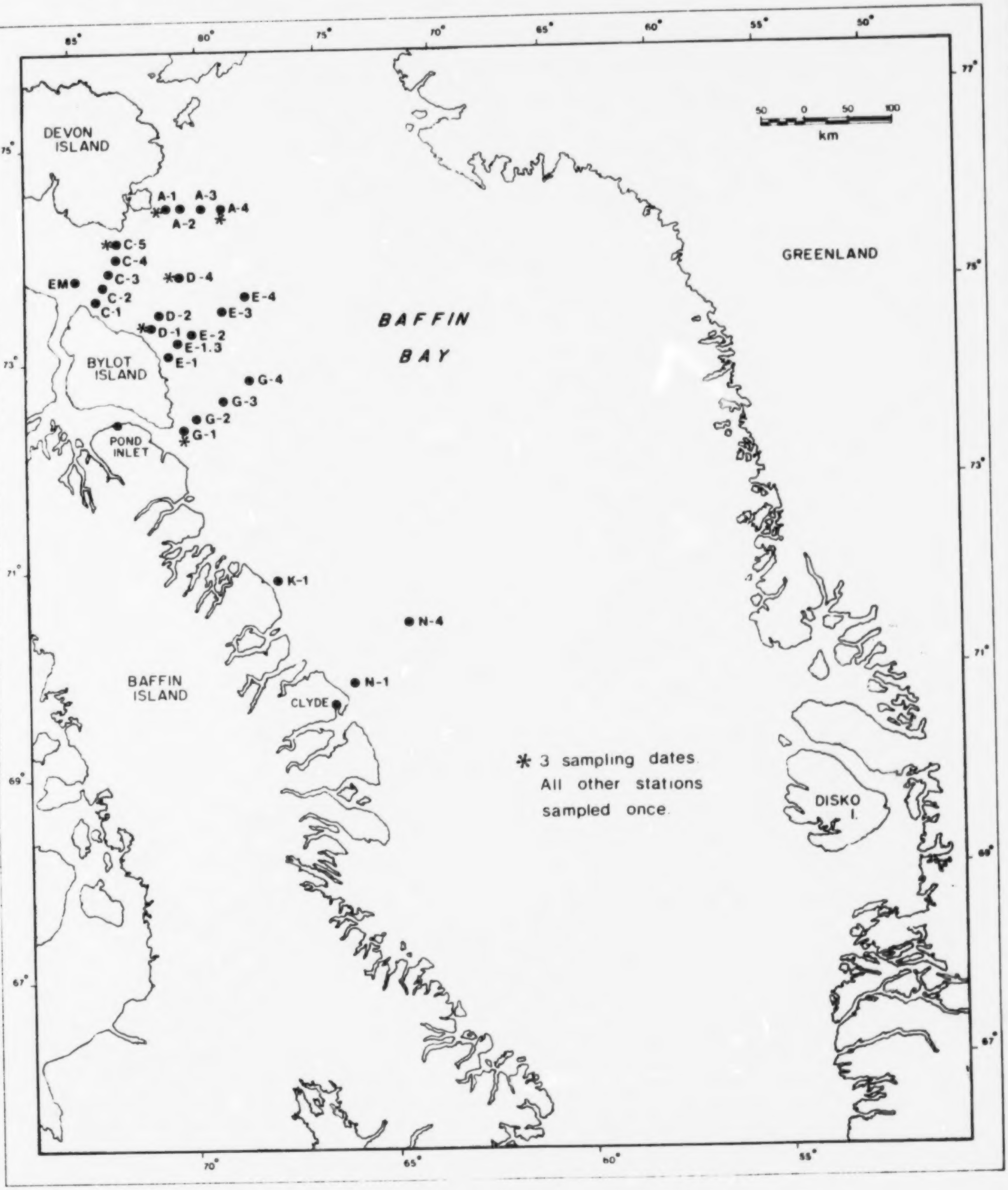
DEVON ISLAND
A-1
A-2
A-3
A-4
C-5
C-4
C-3
C-2
C-1
EM
D-4
D-2
D-1
E-4
E-3
E-2
E-1.3
E-1
BYLOT ISLAND
G-4
G-3
G-2
G-1
POND INLET
BAFFIN BAY
GREENLAND
K-1
N-4
N-1
CLYDE
BAFFIN ISLAND
DISKO I.
50 0 50 100
km
* 3 sampling dates. All other stations sampled once.
85°
80°
75°
70°
65°
60°
55°
50°
77°
75°
73°
71°
69°
67°

FIG. 2.3.2 Locations of offshore stations at which samples were analysed for phytoplankton in eastern Lancaster Sound-western Baffin Bay, 23 July to 10 October 1978.

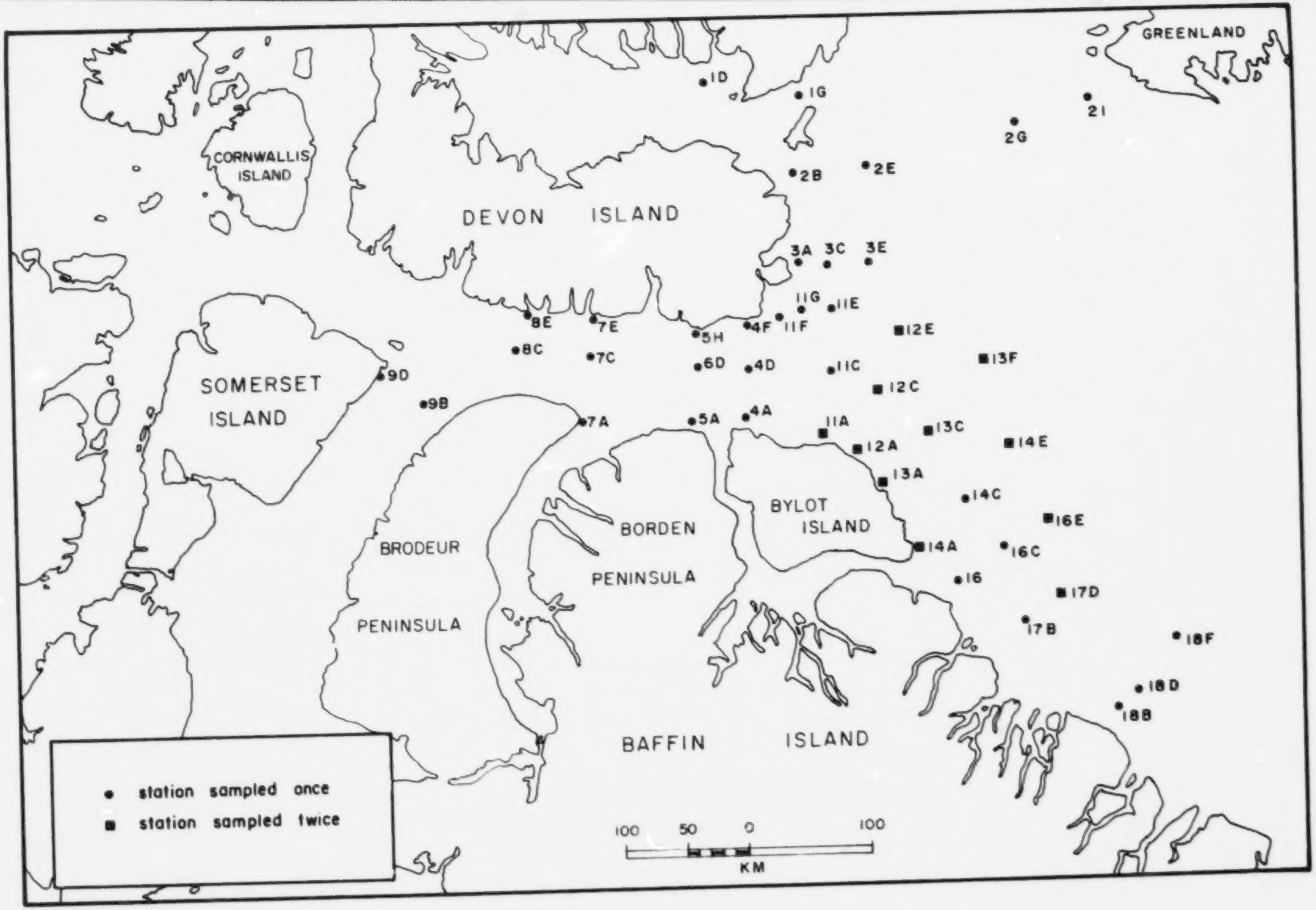
GREENLAND
CORNWALLIS ISLAND
DEVON ISLAND
SOMERSET ISLAND
BRODEUR PENINSULA
BORDEN PENINSULA
BYLOT ISLAND
BAFFIN ISLAND
1D
1G
21
2G
2B
2E
3A
3C
3E
11G
11E
8E
7E
5H
4F
11F
12E
8C
7C
6D
4D
11C
13F
9D
12C
9B
7A
5A
4A
11A
13C
12A
14E
13A
14C
16E
14A
16C
16
17D
17B
18F
18D
18B
station sampled once
station sampled twice
100
50
0
100
KM

FIG. 2.3.3. Locations of stations sampled for chlorophyll in Lancaster Sound and northwest Baffin Bay, 3 August to 5 September 1979. From Dunlop and Thomson (MS).

secondary producers in Lancaster Sound and northwest Baffin Bay. As further explained in Section 4.0: Trophic Relationships, plankton are of great importance in the study area, since much of the energy flow to seabirds and marine mammals originates from the planktonic system.

The following material summarizes present knowledge of plankton in the study area. Most of the information was obtained in 1978 and reported by Sekerak *et al*. (1979) and Buchanan and Sekerak (1982).

2.3.1 Phytoplankton

Research on phytoplankton in the study area dates back to 1894 when the Swedish explorer Nilsson collected samples from Pond Inlet, and near north Bylot Island and northeast Baffin Island. The second scientific investigation in the area was the *Godthaab* expedition in 1928 which collected a few samples in eastern Lancaster Sound and near Bylot Island. No further phytoplankton research was performed in the region until environmental studies began in relation to possible hydrocarbon exploration. The first quantitative collections in Lancaster Sound were obtained in 1976 (Sekerak *et al*. 1976b) and this base of information was greatly expanded in 1978 (Sekerak *et al*. 1979) and to a lesser extent in 1979 (Dunlop and Thomson MS) during the EAMES program. Sampling for chlorophyll and phytoplankton in 1978 took place in surface waters (0, 5, 10, 15, 25 and 50 m) at locations shown in Figures 2.3.1 and 2.3.2. Sampling in 1979 was limited to determining chlorophyll concentrations at stations shown in Figure 2.3.3.

2.3.1.1 Community Composition

The phytoplankton community of eastern Lancaster Sound and northwest Baffin Bay between 23 July and 10 October 1978 was typical of summer phytoplankton communities found in other studies of Canadian arctic waters --Bridport Inlet, Melville Island (Buchanan *et al*. 1977); west Barrow Strait and Austin Channel (Thomson *et al*. 1975); Assistance Bay, Cornwallis Island, and Creswell Bay, Somerset Island (Sekerak *et al*. 1976a); Jones Sound (Apollonio 1976b); Frobisher Bay (Bursa 1971; Grainger 1971); and Foxe Basin (Bursa 1961). Diatoms, principally centric diatoms, dominated the phytoplankton assemblage (73% of total cell numbers). Similarly, Sekerak *et al*. (1976b) found that diatoms contributed 74% to cell numbers in Lancaster Sound in 1976. Other groups that contributed significant numbers were micro-flagellates, miscellaneous organisms that appeared to be algal spores, and the chrysophyte *Dinobryon balticum*. Dinoflagellates were less abundant, and smaller numbers of euglenophytes, chlorophytes and choanoflagellates (Craspedophyceae) occurred sporadically.

The centric diatom *Chaetoceros socialis* was, on average, the most abundant species. However, it did not completely dominate the summer phytoplankton community as has been found in other studies of Canadian arctic waters, including Lancaster Sound in 1976. Instead, a greater number of species contributed significantly to total cell counts in 1978. Other abundant species were *Nitzschia grunowii*, *Chaetoceros compressus*, *C. laciniosus*, *C. wighamii*, *Thalassiosira gravida*, *Achnanthes taeniata*, *Nitzschia cylindrus* and *N. seriata* (Table 2.3.1).

TABLE 2.3.1 Cell numbers of major phytoplankton taxa and dominant phytoplankton species in eastern Lancaster Sound and western Baffin Bay,[1] 23 July to 10 October 1978. N = 215 samples in all cases.

Taxon	Cell Numbers/L ($x10^4$)			% of Total[2]
	$\bar{X}$	S.D.	Range	
Chlorophyceae	<0.1	<0.1	0.00-0.25	<0.5
Euglenophyceae	<0.1	0.1	0.00-0.47	<0.5
Bacillariophyceae	13.4	26.3	0.00-101.79	73.2
Centrales	9.0	14.7	0.00-98.39	49.2
Chaetoceros compressus	1.5	4.7	0.00-37.91	8.2
C. debilis	0.2	0.7	0.00-5.61	1.1
C. furcellatus	0.1	0.8	0.00-9.52	0.5
C. laciniosus	0.5	1.7	0.00-15.47	2.7
C. septentrionalis	0.2	1.3	0.00-15.25	1.1
C. socialis	3.7	7.2	0.00-41.10	20.2
C. wighamii	1.1	2.7	0.00-24.99	6.0
Eucampia zodiacus	0.1	0.3	0.00-3.06	0.5
Porosira glacialis	<0.1	0.1	0.00-0.51	<0.5
Thalassiosira condensata	0.1	0.7	0.00-8.22	0.5
T. fluviatilis	0.1	0.4	0.00-3.57	0.5
T. frigida	0.1	0.5	0.00-6.33	0.5
T. gravida	0.6	1.7	0.00-13.26	3.3
T. nordenskioeldii	0.2	0.8	0.00-5.86	1.1
T. polychorda	0.1	0.2	0.00-1.15	0.5
Pennales	4.4	11.6	0.00-75.44	24.0
Achnanthes taeniata	0.6	2.5	0.00-22.61	3.3
Nitzschia cylindrus	0.5	3.5	0.00-37.61	2.7
N. grunowii	1.9	5.4	0.00-34.34	10.4
N. seriata	0.5	2.2	0.00-19.89	2.7
Craspedophyceae	<0.1	<0.1	0.00-0.55	<0.5
Chrysophyceae	1.4	3.7	0.00-30.94	7.7
Dinobryon balticum	1.4	3.7	0.00-30.94	7.7
Dinophyceae	0.1	0.2	0.00-0.89	0.5
Peridinium breve	<0.1	0.1	0.00-0.62	<0.5
P. minusculum	<0.1	<0.1	0.00-0.25	<0.5
P. pellucidum	<0.1	0.1	0.00-0.49	<0.5
Microflagellates	1.7	2.1	0.06-18.27	9.3
Miscellaneous	1.6	2.2	0.00-10.41	8.7
TOTAL CELLS	18.3	21.4	0.30-110.54	100.0

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[1] Dominant species defined as those which comprised ≥5% of total cell numbers in any one sample *and* occurred in 20 or more of the 215 samples.

[2] Taxon mean divided by total cell mean x 100.

2.3.1.2 Multivariate Comparisons

Spatial and temporal variations in the composition and standing stock of the phytoplankton community are the result of many factors. Physical (e.g. temperature, light intensity, light wavelength, wind), chemical (salinity, nutrient concentrations) and biological (zooplankton grazing, competition) factors all interact to determine the phytoplankton community at any place and time. To date, research on phytoplankton in the study area has been largely of a survey nature and generally has not been designed to elucidate causative relationships. Modern multivariate statistical techniques are useful in obtaining insight into complex relationships where variables are essentially uncontrolled, and, to this end, data obtained in 1978 were subjected to stepwise multiple regression analyses. Dependent variables employed in the analyses were chlorophyll, total cell counts and group cell counts, while predictor variables were sampling depth, water depth, temperature, salinity, nitrate + nitrite, orthophosphate, reactive silicate, date, time of day and location along a line running northwest/southeast through the study area. Results are summarized below and are explained in greater detail in Sekerak et al. (1979).

A multiple regression equation accounted for 41% of the variance in chlorophyll a concentration. Nutrient concentrations, water temperature and salinity were all found to be correlated with phytoplankton standing stock, and are all believed to be important in controlling phytoplankton abundance. Chlorophyll a concentrations were high when nutrient concentrations and water temperature were low and when salinity was high.

Significant vertical and horizontal variations in chlorophyll a concentration were observed. Maximum chlorophyll a concentrations were generally found at a subsurface depth shallower than 50 m, although near the end of the study period (late September-early October) chlorophyll a was quite evenly distributed throughout the top 25 m. Chlorophyll a concentrations also tended to be higher in shallow nearshore waters than in deeper offshore waters. However, geographic variations in chlorophyll a concentration in five different regions of the study area were transitory, and over the study period as a whole were not significant. Chlorophyll a concentrations did not appear to vary significantly with date.

Statistical analyses of total cell counts were less powerful than those of chlorophyll a concentration because fewer samples were analysed for their cell counts than for chlorophyll a concentration. Total cell counts, like chlorophyll a values, tended to be high when nutrient concentrations and water temperature were low. However, relationships of cell counts with particular predictor variables differed considerably among various taxonomic groups.

Diatoms, particularly centric diatoms, dominated the phytoplankton community. Of all the taxonomic groups, their relationships to the predictor variables were most similar to those of chlorophyll a concentration. Like chlorophyll a, diatoms were found in highest concentrations where nutrient concentrations and water temperature were low, and their densities were generally inversely related to water depth. However, unlike chlorophyll a concentrations, diatom numbers were not strongly correlated with salinity, and numbers of centric diatoms increased through the season.

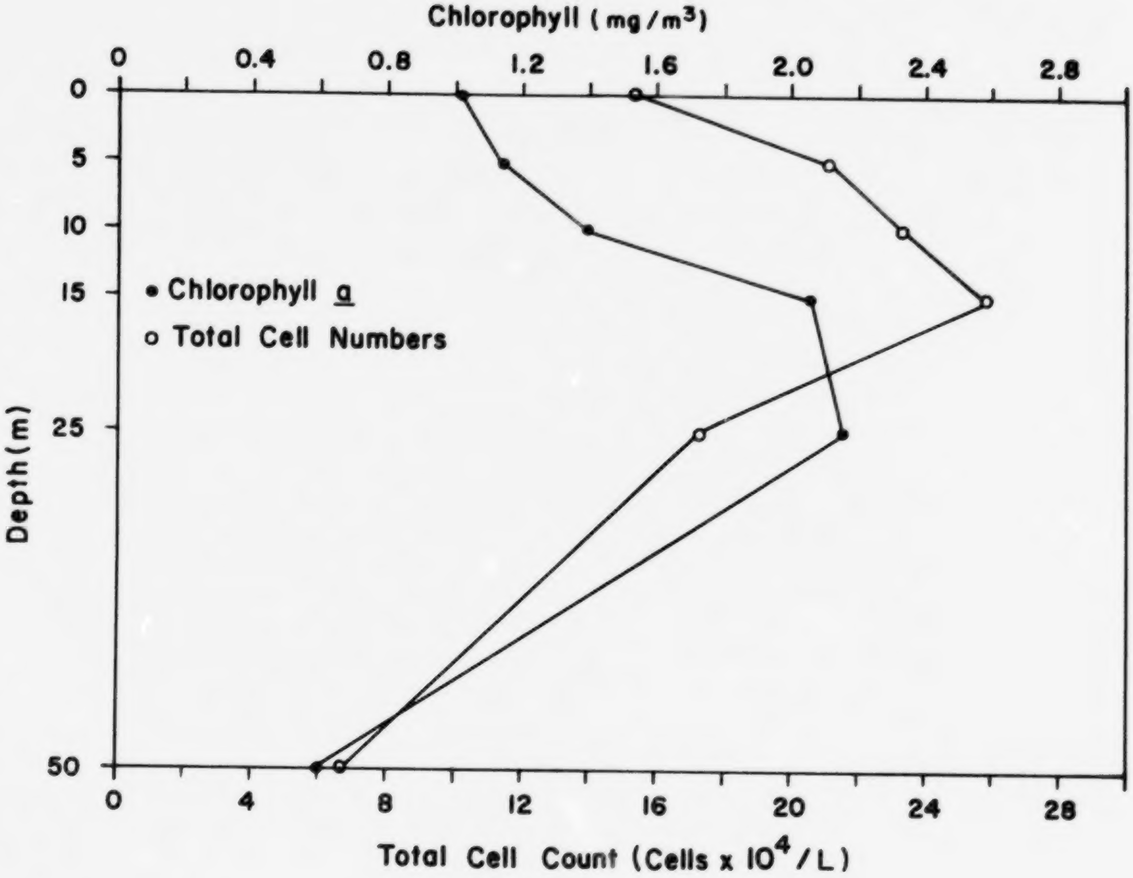


FIG. 2.3.4 Depth profiles of mean chlorophyll a concentrations and mean total cell numbers from eastern Lancaster Sound and western Baffin Bay, 1978. (N = 820 for chlorophyll a measurements; 215 for total cell number measurements.)

The abundances of other taxonomic groups, although inversely related to nutrient concentrations in the same manner as were chlorophyll a values and diatom numbers, differed in their relationships to other variables. Chrysophyte and dinoflagellate numbers were maximal at the surface and declined with depth. Abundances of these two groups, along with microflagellates, were positively related to water temperature. Microflagellates and miscellaneous organisms were found in higher numbers in the deeper offshore waters than in the more shallow nearshore waters. Miscellaneous organisms, unlike centric diatoms, appeared to decrease in number with date.

Other factors that were not measured during this study undoubtedly affect phytoplankton standing stock. Zooplankton grazing pressure, light intensity and wavelength, and the rate of nutrient replenishment are expected to be among the most important of these.

Three of the most pertinent predictor variables, depth, location and time, are discussed in more detail below.

Depth

The depth distribution of phytoplankton standing stock in the upper 50 m in 1978 is shown in Figure 2.3.4. Both total cell numbers and chlorophyll a concentrations were highest at intermediate depths and both were significantly lower at a depth of 50 m ($p<0.05$), based on multiple comparison tests. As previously explained, chrysophytes and dinoflagellates were most abundant at the surface and Figure 2.3.4 largely reflects the depth distribution of diatoms.

Sekerak *et al*. (1976b) found similar relationships between depth and chlorophyll and cell numbers in Lancaster Sound and such relationships are common in other areas. High light intensities at the water surface often inhibit phytoplankton growth (Fogg 1975; Raymont 1980) and low light levels limit photosynthesis in deep water.

Geographic Location

Based on information available in 1978, the study area was divided into five subareas (Fig. 2.3.5), primarily on the basis of known water currents and distance from shore. Only in the first third of the study (23 July-18 August) did chlorophyll concentrations differ significantly among the five areas. During the first period, chlorophyll concentrations were higher along the east coast of Baffin Island (subarea 5) than in waters near Bylot Island (subarea 2) or in offshore waters of northwest Baffin Bay (subarea 3) (Table 2.3.2).

Total cell counts did not vary significantly among the five subareas but comparisons were hampered by small sample sizes in two of the five subareas. When comparisons were restricted to Subareas 1, 2, and 3 (Table 2.3.3), significantly greater numbers of chrysophytes (*Dinobryon balticum*) and dinoflagellates were found near Devon Island (subarea 1) than in offshore waters (subarea 3).

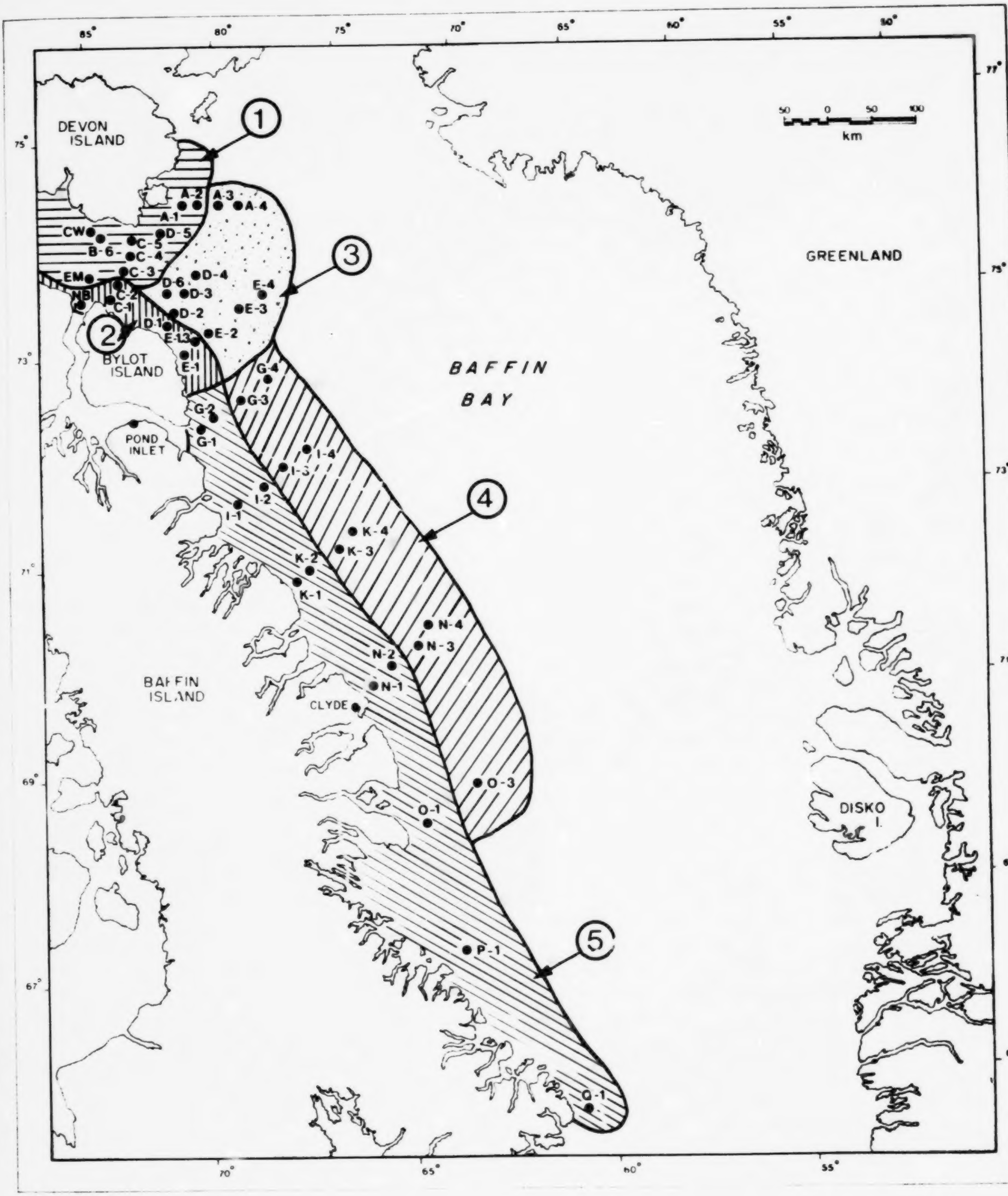

85°
80°
75°
70°
65°
60°
55°
50°
77°
75°
73°
71°
69°
67°
50 0 50 100
km
DEVON ISLAND
GREENLAND
BAFFIN BAY
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
DISKO I.
①
②
③
④
⑤
A-1
A-2
A-3
A-4
CW
B-6
C-5
C-4
C-3
C-2
C-1
D-5
D-4
D-6
D-3
D-2
D-1
E-4
E-3
E-2
E-L3
E-1
EM
NB
G-4
G-3
G-2
G-1
I-4
I-3
I-2
I-1
K-4
K-3
K-2
K-1
N-4
N-3
N-2
N-1
O-3
O-1
P-1
Q-1
70°
65°
60°
55°

FIG. 2.3.5 Locations of the five subareas where chlorophyll concentrations and total cell counts were examined for differences. Subareas were defined on the basis of currents and distance from shore.

TABLE 2.3.2 Depth-integrated chlorophyll a concentrations (mg/m^2) and total cell counts (x10^8/m^2) vs area for different time periods.

		Chlorophyll *a*			Total Cell Counts
Sub-Area*	Statistics	1**	2	3	1
1	$\bar{X}$	75	73	77	85
	S.D.	38	32	24	83
	N	7	8	6	5
2	$\bar{X}$	52	61	61	62
	S.D.	37	21	7	60
	N	6	6	4	4
3	$\bar{X}$	60	94	68	50
	S.D.	35	44	15	40
	N	9	7	8	7
4	$\bar{X}$	60	68	62	9
	S.D.	23	33	26	4
	N	8	4	9	2
5	$\bar{X}$	164	43	92	83
	S.D.	69	11	32	69
	N	6	4	10	4
Kruskal-Wallis ANOVA					
	H	13.04	5.78	7.02	5.36
	P	0.05>P>0.01	>0.05	>0.05	>0.05
Dunn's Mult. Comp. (α = 0.05)		5>2,3	-	-	-

---

* See Figure 2.3.5 for locations of subareas.

** Time period 1 (23 July - 18 August), period 2 (19 August- 17 September) and period 3 (18 September - 10 October).

TABLE 2.3.3 Depth-integrated phytoplankton cell numbers ($x10^8/m^2$) vs area in time period 1 (23 July-18 August 1978).

Group	Area 1*			Area 2			Area 3			Kruskal-Wallis ANOVA		Dunn's Mult. Comp.**
	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	H	P	
Centrales	38.9	57.5	5	29.0	38.8	4	21.9	38.4	7	1.2	>0.05	-
Pennales	8.8	12.8	5	12.9	14.9	4	14.2	21.7	7	0.2	>0.05	-
Chrysophyceae	19.1	18.1	5	2.9	3.4	4	0.8	0.6	7	8.9	0.05>P>0.01	1>3
Dinophyceae	0.9	0.5	5	0.4	0.3	4	0.3	0.2	7	7.9	0.05>P>0.01	1>3
Microflagellates	9.6	8.0	5	4.9	2.5	4	5.8	3.1	7	1.0	>0.05	-
Miscellaneous	7.9	7.9	5	11.9	7.9	4	6.9	3.5	7	1.0	>0.05	-
TOTAL CELLS	85.2	83.4	5	62.0	60.0	4	49.9	40.3	7	0.4	>0.05	-

* See Figure 2.3.5 for locations of subareas.

** Significance criterion is $\alpha = 0.05$.

Regression analysis indicated that chlorophyll concentrations and total cell counts declined in relation to distance from shore; however, major groups differed in their relationship to this distance. More diatoms occurred in nearshore than in offshore areas, whereas the reverse relationship was apparent for microflagellates and organisms classified in a miscellaneous category. Hsiao et al. (1977) found similar relationships in the southern Beaufort Sea and speculated that conditions (high nutrient, trace element and vitamin concentrations; low light intensities; warm temperatures) were more favourable for diatoms in waters close to shore. However, in the present study nitrate + nitrite concentrations increased significantly with distance from shore (see Section 2.2) and multiple regression analysis indicated that diatom numbers were negatively related to temperature. It is quite possible that nutrients in short supply do not accumulate, but are rapidly utilized by phytoplankton once they become available. It is also clear that no one factor is an overriding determinant of phytoplankton distribution and abundance within the study area.

Time

When the relationship between date and standing stock was analysed in isolation from other variables it was found that, over the study area as a whole, chlorophyll concentrations did not significantly change with time (Table 2.3.4). When the five subareas were considered separately, significant differences were apparent only in subarea 5 where concentrations declined between the first and second period. Similarly, total numbers of phytoplankton exhibited no significant variations with date (Table 2.3.5). Significant differences were encountered only in the cases of centric diatoms and miscellaneous organisms; centric diatoms increased between periods one and three, whereas miscellaneous organisms decreased between the same periods.

The annual cycle of arctic marine phytoplankton has often been described as unimodal (Fogg 1975; Parsons et al. 1977). Bursa (1963), however, concluded that a bimodal cycle regularly occurred, albeit compressed in time in comparison with the annual cycle in temperate waters. He noted that a bloom of pennate diatoms was followed by a bloom of centric diatoms. Bain et al. (1977) summarized available data, which strongly indicated that the bimodal cycle described by Bursa was a common occurrence in arctic regions. A diagrammatic representation of this cycle is presented in Figure 2.3.6.

It is apparent that planktonic primary production was well underway in Lancaster Sound and northwest Baffin Bay earlier in the year than late July or early August, when observations began in 1978 and 1979. Available data concerning relationships between phytoplankton standing stock and dates are incomplete. For example, Apollonio (1976b) found that maximum phytoplankton development occurred in Jones Sound in July, while ice cover was still intact. The increase in centric diatoms with time noted in the study area in 1978 is in accord with known cycles of arctic phytoplankton. However, it is quite probable that pennate diatoms were more abundant in spring and early summer and that they accounted for a significant portion of annual production.

TABLE 2.3.4 Depth-integrated chlorophyll *a* concentrations (mg/m^2) *vs* date for 5 areas and all areas combined. Time periods are 23 July-18 August (period 1), 19 August-17 September (period 2) and 18 September-10 October (period 3).

	Period 1			Period 2			Period 3			Kruskal-Wallis ANOVA		
Area*	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	H	P	Mult. Comp.**
1	79.1	37.0	8	68.3	30.9	7	77.2	24.1	6	0.85	>0.05	-
2	51.7	36.8	6	59.8	23.8	5	60.8	7.5	4	1.40	>0.05	-
3	60.0	35.1	9	90.9	42.1	8	67.6	15.4	8	3.45	>0.05	-
4	59.8	23.3	8	68.0	33.3	4	62.3	26.5	9	0.51	>0.05	-
5	164.3	68.8	6	42.5	11.0	4	92.9	30.3	11	13.04	0.01>P>0.001	1>2
All	79.6	54.8	37	69.5	33.9	28	74.5	26.4	38	1.06	>0.05	-

* See Figure 2.3.5 for locations of subareas.

** Significance criterion is $\alpha = 0.05$.

TABLE 2.3.5 Depth-integrated cell numbers $(x10^8/m^2)$ of major phytoplankton groups and total phytoplankton vs. date. Time periods are 23 July-18 August (period 1), 19 August-17 September (period 2) and 18 September-10 October (period 3). Date from areas 1, 2 and 3 pooled in analysis.*

Group	Period 1			Period 2			Period 3			Kruskal-Wallis ANOVA		Dunn's Mult. Comp.**
	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	H	P	
Centrales	29.0	42.7	16	60.2	58.3	6	110.4	67.5	6	9.39	0.01>P>0.001	3>1
Pennales	12.2	16.8	16	2.8	2.3	6	18.9	14.5	6	5.35	>0.05	-
Chrysophyceae	7.0	12.7	16	6.4	4.7	6	3.2	4.4	6	3.47	>0.05	-
Dinophyceae	0.5	0.4	16	0.6	0.3	6	0.7	0.5	6	1.43	>0.05	-
Microflagellates	6.7	5.1	16	12.8	9.5	6	4.5	3.2	6	4.36	>0.05	-
Miscellaneous	8.5	6.2	16	3.0	0.8	6	1.1	0.8	6	11.51	0.01>P>0.001	1>3
Total	64.1	58.9	16	86.1	62.0	6	138.8	76.1	6	5.33	>0.05	-

* See Figure 2.3.5 for locations of subareas.

** Significance criterion is $\alpha = 0.05$.

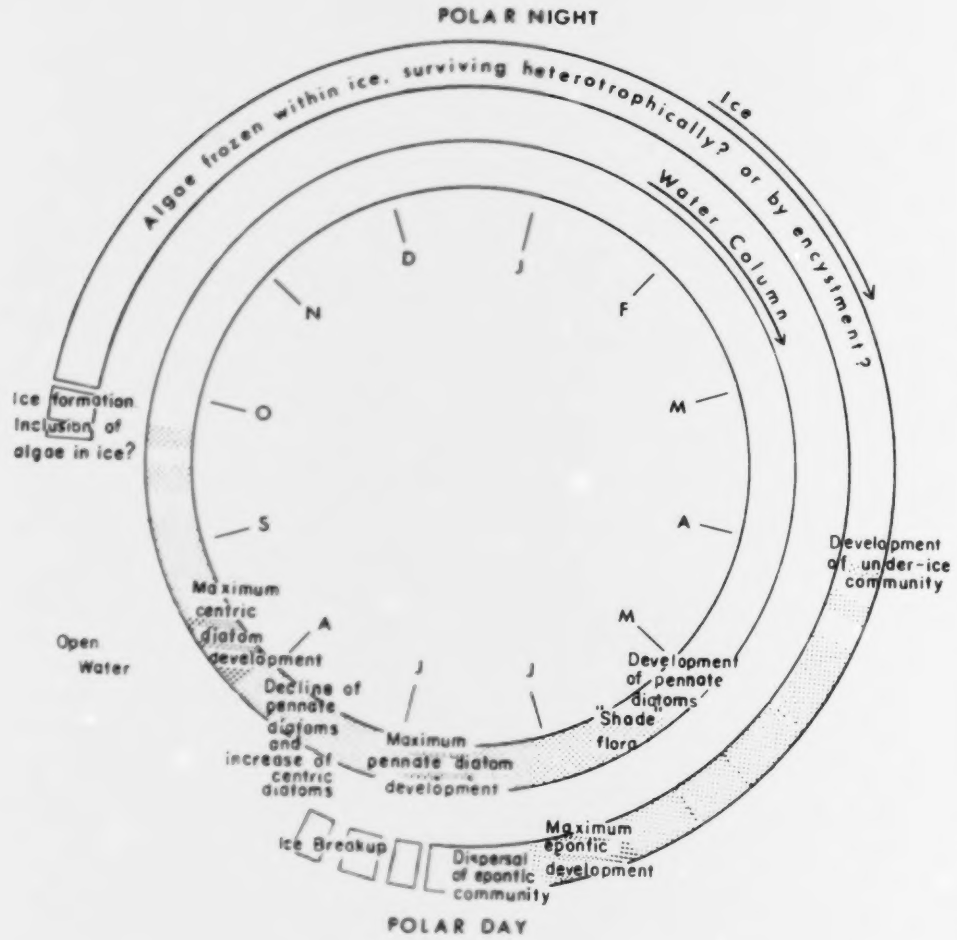

POLAR NIGHT
Algae frozen within ice, surviving heterotrophically? or by encystment?
Ice
Water Column
D
J
F
M
A
M
J
J
A
S
O
N
Ice formation
Inclusion of algae in ice?
Development of under-ice community
Maximum centric diatom development
Open Water
Decline of pennate diatoms and increase of centric diatoms
Maximum pennate diatom development
Development of pennate diatoms
"Shade" flora
Maximum epontic development
Ice Breakup
Dispersal of epontic community
POLAR DAY

FIG. 2.3.6 Annual cycle of phytoplankton and epontic algal development in arctic waters. Timing of events is only approximate and some relationships are not clearly understood. Taken from Bain et al. (1977); based on the work of Bursa (1961, 1971), Appollonio (1965), Horner (1977), Thomson et al. (1975), Sekerak et al. (1976a,b), and Bain et al. (1977).

2.3.1.3 Annual and Regional Comparisons

Standing stock of phytoplankton, as reflected by concentrations of chlorophyll a, in eastern Lancaster Sound and northwest Baffin Bay in 1978 and 1979 appeared to be lower than that found by Sekerak et al. (1976b) in Lancaster Sound in 1976 (Table 2.3.6). The areas from which information was gathered in 1978 and 1979 overlapped only slightly with the 1976 study area, thereby confounding the above comparison. However, three sampling locations (Cape Warrender, north Navy Board Inlet and east-central Lancaster Sound) were common to the 1976 and 1978 studies and were sampled on approximately the same date in both years. At these locations chlorophyll concentrations were significantly higher in 1976 than in 1978 (Sekerak et al. 1979:126). The ratio of mean chlorophyll in 1976 to that in 1978 was 1.00 : 0.77. The cause of this apparent variation is unknown. Ice break-up and clearance were comparatively late in 1978 and 1979 as opposed to 1976, and different light and salinity regimes could affect standing stock. It should be noted that present information is insufficient to determine if total annual production was also variable.

Because of the above variability, only broad comparisons of standing stock in Lancaster Sound and northwest Baffin Bay with standing stocks in other areas are possible. Available data suggest that phytoplankton standing stock in Lancaster Sound and northwest Baffin Bay in 1976, 1978 and 1979 was generally lower than in Frobisher Bay in 1967 and 1969, a considerable distance to the south, but substantially higher than that found in the Beaufort Sea (Table 2.3.6).

2.3.2 Zooplankton

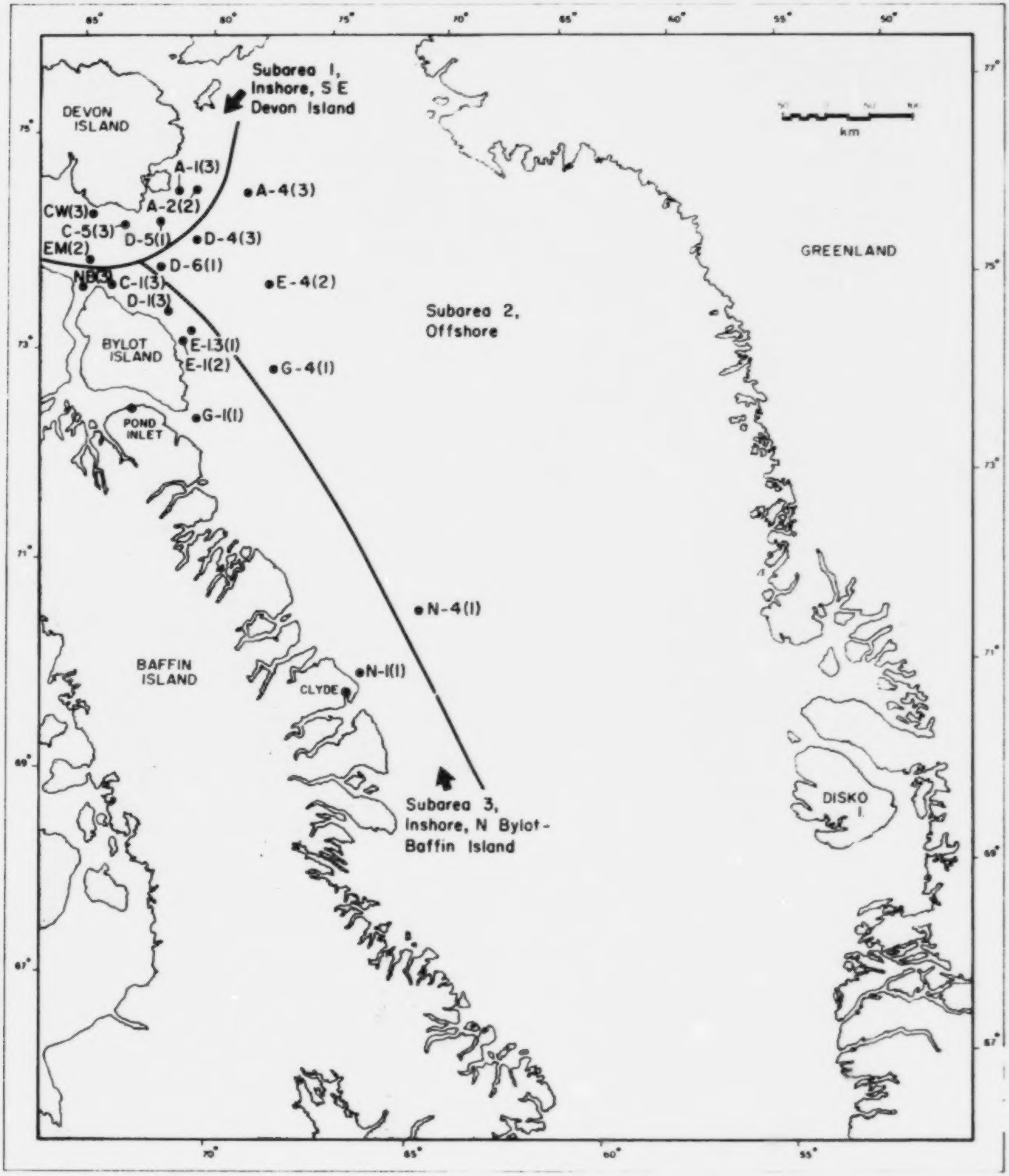
Studies of zooplankton in Baffin Bay and eastern Lancaster Sound appear to have begun in 1928 with the Godthaab expedition. Resultant reports were Jespersen (1934) on copepods, Wesenberg-Lund (1936) on polychaetes, and Kramp (1939, 1942a,b,c, 1961) on chaetognaths, jellyfish, combjellies, tunicates and pteropods, respectively. Dunbar (1941a, 1942, 1964) gives distribution records for various zooplankton species in coastal waters near Pond Inlet and Clyde River (as well as more southern areas) and Kerswill (1940) reported pteropods from Pond Inlet. Grainger (1963) reported some results on copepods from zooplankton collections taken in Baffin Bay and eastern Lancaster Sound from 1954 to 1961. Tidmarsh (1973) investigated copepods in north Baffin Bay and Kane Basin, somewhat to the north of the present area of interest.

The above reports are primarily of a taxonomic and distributional nature. Of ecological interest are reports by Dunbar (1941b) on the breeding cycle of the chaetognath *Sagitta elegans*; Dunbar (1946) on the importance of the amphipod *Parathemisto libellula* in the diet of the ringed seal; Jaschnov (1961) and Grainger (1963) on the use of copepods as indicators of water masses of origin; and Grainger (1965) and Tidmarsh (1973) on copepod life cycles.

More concentrated research on zooplankton in the study area was performed in 1976 and reported by Sekerak et al. (1976b). Six stations in Lancaster Sound were sampled five times in the open water period and information was obtained on the depth distribution of zooplankton to 150 m. Information on the importance of zooplankton in the diets of seabirds was also obtained as part of the same study and was reported by Bradstreet (1976).

TABLE 2.3.6 Mean chlorophyll a concentrations (mg/m^3) found at several depths between 23 July and 10 October in various arctic and subarctic waters. From Sekerak et al. (1979).

Area	Date	Reference	Statistics	Depth						
				0	5	10	15	20	25	50
E Lancaster	23 July	This study	$\bar{X}$	1.02	1.14	1.39	2.06	-	2.16	0.60
Sound-NW	to 10 Oct.,		S.D.	0.68	0.92	0.89	1.73	-	1.83	0.50
Baffin Bay	1978		N	147	132	144	132	-	136	130
Lancaster	23 July to	Sekerak	$\bar{X}$	1.23	-	1.77	-	-	2.51	0.93
Sound	13 Sept.,	*et al.*	S.D.	1.28	-	1.59	-	-	2.53	0.90
	1976	1976b	N	30	-	30	-	-	30	30
Davis St.	1 Aug. to	MacLaren	$\bar{X}$	0.95	1.11	-	-	1.16	-	1.29
and Hudson	22 Sept.,	Atlantic	S.D.	1.07	1.60	-	-	1.73	-	1.84
St.	1977	Ltd. 1978	N	47	47	–	-	47	-	47
Frobisher	5 Aug. to	Grainger	$\bar{X}$	1.55	2.71	3.16	-	2.48	-	1.58
Bay	12 Sept.,	1971	S.D.	0.70	2.20	1.66	-	1.82	-	1.10
	1967		N	6	6	6	-	6	-	6
Frobisher	27 July to	Grainger	$\bar{X}$	2.11	3.17	3.30	-	3.45	-	2.59
Bay	5 Sept.,	1971	S.D.	0.96	1.31	1.54	-	1.85	-	1.49
	1969		N	10	10	10	-	7	-	7
Beaufort	29 July to	Grainger	$\bar{X}$	1.36	0.67	0.19	-	0.10	-	0.12
Sea	2 Sept.,	and Lovrity	S.D.	0.81	0.49	0.22	-	0.08	-	0.10
	1974	1975	N	9	9	9	-	8	-	7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55°
Subarea 1, Inshore, S E Devon Island
DEVON ISLAND
km
A-1(3)
A-4(3)
A-2(2)
CW(3)
C-5(3)
D-5(1)
D-4(3)
EM(2)
D-6(1)
NB(3)
C-1(3)
E-4(2)
D-1(3)
GREENLAND
Subarea 2, Offshore
BYLOT ISLAND
E-1.3(1)
E-1(2)
G-4(1)
G-1(1)
POND INLET
N-4(1)
BAFFIN ISLAND
N-1(1)
CLYDE
DISKO I.
Subarea 3, Inshore, N Bylot-Baffin Island

FIG. 2.3.7 Locations of zooplankton collections, 23 July to 10 October 1978, and boundaries of the three subareas discussed in the text. Numbers in parentheses indicate the number of times stations were sampled.

TABLE 2.3.7 Mean abundance and biomass of major groups of zooplankton in eastern Lancaster Sound and western Baffin Bay, 23 July to 10 October 1978. D = damaged and, therefore, uncountable; P = present in samples in quantities <1.0 mg and, therefore, unweighable.

Depth (m)	50-0 (n=39)				150-50 (n=38)				250-150 (n=38)			
	Abundance		Biomass		Abundance		Biomass		Abundance		Biomass	
Group	mean no./m³	% of total	mean mg/m³	% of total	mean no./m³	% of total	mean mg/m³	% of total	mean no./m³	% of total	mean mg/m³	% of total
Hydrozoa	6.05*	1.11	7.53	1.88	0.72*	0.85	1.77	2.09	0.53*	0.87	5.06	4.75
Ctenophora	0.04	0.01	1.80	0.45	D	D	2.87	3.38	<0.01*	0.01	28.99	27.21
Polychaeta (mostly larvae)	5.14	0.94	0.03	0.01	0.24	0.28	<0.01	<0.01	0.15	0.25	0.01	0.01
Gastropoda	24.90	4.56	18.46	4.62	1.51	1.79	0.06	0.07	1.08	1.77	1.12	1.05
Bivalvia (young)	1.94	0.36	P	P	0.23	0.27	P	P	0.05	0.08	P	P
Myodocopa	0.13	0.02	0.07	0.02	0.31	0.37	0.19	0.22	0.85	1.39	0.55	0.52
Cirripedia (larvae)	1.88	0.34	0.01	0.01	0.13	0.15	P	P	0.05	0.69	P	P
Copepoda	481.53	88.23	334.29	83.59	78.66	93.07	71.73	84.60	55.78	91.46	61.88	58.09
Calanoida	346.17	63.42	332.87	83.24	63.42	75.04	71.61	84.46	45.76	75.03	61.80	58.01
Harpacticoida	0.50	0.09	P	P	0.04	0.05	P	P	0.05	0.08	<0.01	<0.01
Cyclopoida	134.86	24.71	1.42	0.36	15.20	17.98	0.12	0.14	9.96	16.33	0.08	0.08
Mysidae, Cumacea and Euphausiidae	0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.10	0.12	0.01	0.02	0.09	0.08
Isopoda	0.10	0.02	<0.01	<0.01	0.03	0.04	P	P	0.03	0.05	P	P
Amphipoda	1.60	0.29	16.06	4.02	0.58	0.69	2.91	3.43	0.29	0.48	3.39	3.18
Decapoda	<0.01	<0.01	0.04	0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Echinodermata (plutei)	19.30	3.54	P	P	1.11	1.31	P	P	0.34	0.56	P	P
Asteroidea (juveniles)	<0.01	<0.01	P	P	0.03	0.04	P	P	0.01	0.02	P	P
Chaetognatha	3.24	0.59	19.41	4.85	0.97	1.15	5.16	6.09	1.66	2.72	5.32	4.99
Larvacea	Uncounted, unweighed. In general terms larvaceans *Fritillaria borealis* and especially *Oikopleura vanhoeffeni* were common (about 1 to 50/m³) in the water column. Both were most abundant in the 50 to 0 m depth interval.											
Osteichthyes	0.03	0.01	2.18	5.45	-	-	-	-	<0.01	<0.01	0.13	1.22
Grand Total**	545.75		399.90		84.52		84.79		60.99		106.53	

TABLE 2.3.7 (Cont'd)

Depth (m)	1200 (or bottom)-250 (n=34)				1900-1200 (n=1)			
	Abundance		Biomass		Abundance		Biomass	
Group	mean no./m^3	% of total	mean mg/m^3	% of total	mean no./m^3	% of total	mean mg/m^3	% of total
Hydrozoa	0.59*	1.58	5.30	5.10	0.04	0.41	31.30	51.09
Ctenophora	0.02*	0.05	4.27	4.11	-	-	-	-
Polychaeta (mostly larvae)	0.18	0.48	0.29	0.28	0.01	0.10	P	P
Gastropoda	0.17	0.45	1.22	1.17	-	-	-	-
Bivalvia (young)	<0.01	<0.03	P	P	-	-	-	-
Myodocopa	2.16	5.78	1.68	1.62	0.06	0.62	0.10	1.63
Cirripedia (larvae)	0.01	<0.03	P	P	-	-	-	-
Copepoda	33.28	88.98	63.95	61.54	9.46	97.53	4.35	7.10
Calanoida	31.64	84.60	63.95	61.54	6.13	63.20	4.35	7.10
Harpacticoida	0.03	0.08	<0.01	<0.01	0.08	0.82	P	P
Cyclopoida	1.61	4.30	<0.01	<0.01	3.25	33.51	P	P
Mysidae, Cumacea and Euphausiidae	0.05	0.13	3.30	3.18	-	-	-	-
Isopoda	0.02	0.05	P	P	0.02	0.21	P	P
Amphipoda	0.24	0.64	2.25	2.17	0.04	0.41	0.92	1.50
Decapoda	0.01	0.03	1.85	1.78	0.06	0.62	24.60	40.15
Echinodermata (plutei)	0.02	0.05	P	P	-	-	-	-
Asteroidea (juveniles)	<0.01	<0.03	P	P	-	-	-	-
Chaetognatha	0.90	2.41	19.70	18.76	-	-	-	-
Larvacea								
Osteichthyes	-	-	-	-	-	-	-	-
Grand Total**	37.40		103.92		9.70		61.27	

* Additional damaged specimens not included

** Including additional minor groups

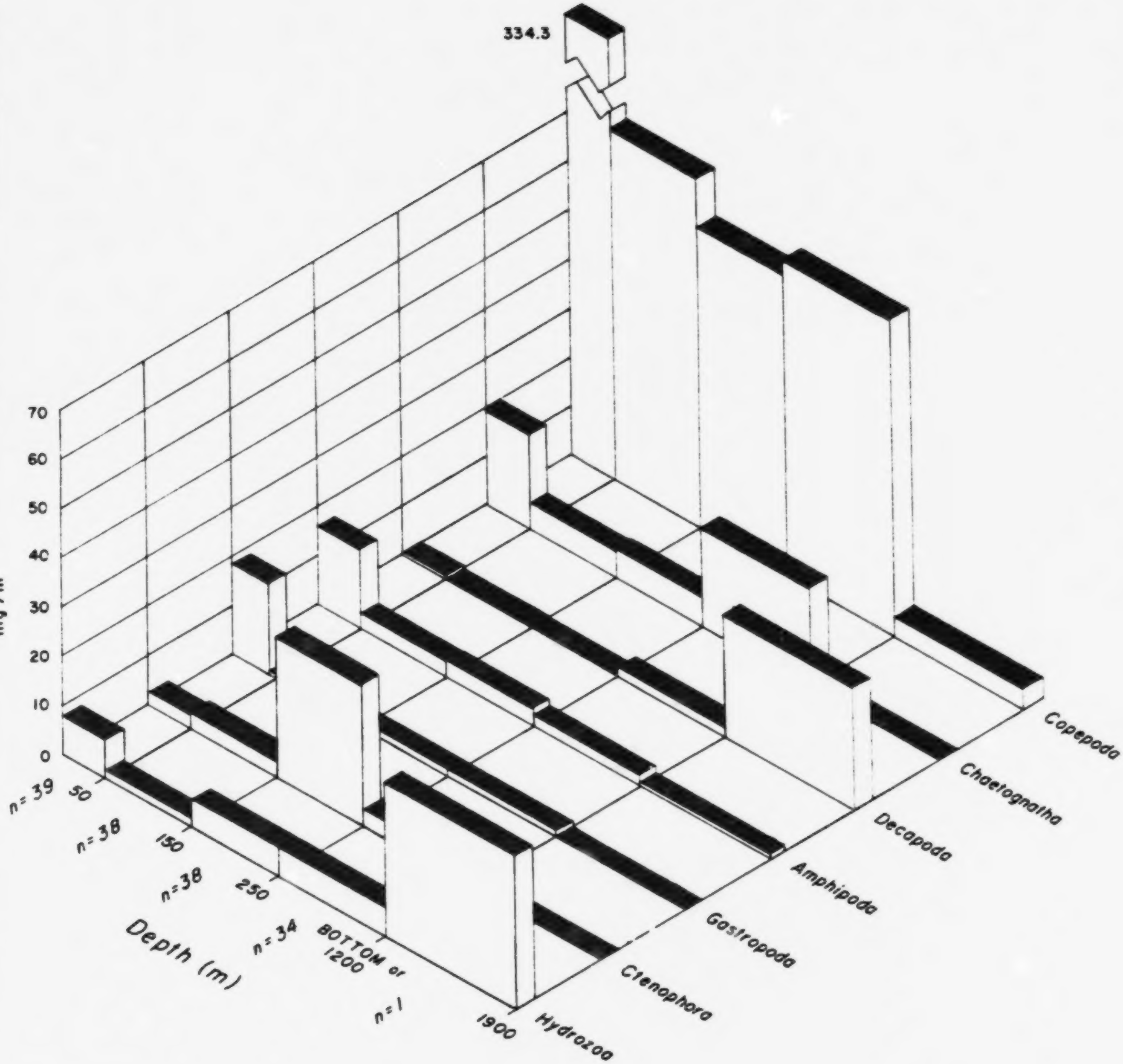


FIG. 2.3.8 Mean biomass (mg/m^3) of the seven most common groups of zooplankters in five depth intervals in eastern Lancaster Sound and western Baffin Bay in 1978. Ctenophore biomass in the depth interval 250 to 150 m is misleading due to unusually large numbers in one sample.

Zooplankton in eastern Lancaster Sound and northwest Baffin Bay was investigated in 1978 as part of the EAMES program, and data from 19 stations are available (Fig. 2.3.7). The regular sampling program included vertical net tows through depths of 50 to 0 m, 150 to 50 m, 250 to 150 m and from the bottom (usually 600 to 800 m) to 250 m. Depths below 1200 m were occasionally sampled. Additional details of the sampling programs are described in Sekerak _et al._ (1979) and Buchanan and Sekerak (1982). Studies in 1978 and 1979 included research on seabird and marine mammal feeding habits, and the zooplankton component of diets of seabirds is described by Bradstreet (1979b, 1980a).

2.3.2.1 Community Composition

All major groups of zooplankton collected in northwest Baffin Bay and eastern Lancaster Sound in 1976 and 1978 (Table 2.3.7) are common to arctic regions (Grainger 1965). As in other arctic regions, copepods were the most important group of zooplankton, in both total numbers and total biomass, in the upper 1200 m of water (Fig. 2.3.8). Other important groups were chaetognaths, amphipods, gastropods, and to a lesser degree ctenophores and hydrozoans. (It should be noted that net samples, such as those obtained in this study, commonly underestimate the abundance of the last two groups). Shrimp (_Hymenodora glacialis_) and hydrozoans replaced copepods as the principal contributors to biomass in the one analysed sample from below 1200 m. In the upper 150 m of water, the contributions of the common groups of zooplankton to total biomass in the 1978 study area were quite similar to those in Lancaster Sound in 1976 (Table 2.3.8).

Planktonic Young of Benthic Invertebrates

Planktonic young of benthic invertebrates were relatively common. When the study area was subdivided into three portions (inshore near southeast Devon Island, inshore near Bylot Island, offshore Baffin Bay--see Fig. 2.3.7), significantly more echinoderm plutei were found near southeast Devon Island, but barnacle nauplii were significantly more common near Bylot Island. Differences in substrate and water depth are thought to be responsible for the geographic differences in abundances of planktonic stages of these benthic invertebrates. Offshore waters contained lower densities of echinoderm plutei, polychaete young, bivalve larvae and barnacle nauplii. All benthic invertebrate young were most common in the upper 50 m of water.

Gastropods, Jellyfish and Combjellies

The gastropods _Limacina helicina_ and _Clione limacina_ and the hydrozoans _Aglantha digitale_ and _Aeginopsis laurentii_ were relatively common only in the upper 50 m of water. The distribution of _A. digitale_ is unusual in comparison to many other zooplankters, in that significantly more specimens were recovered from offshore than from inshore waters. However, such a distribution is not unusual for the species (Kramp 1942a). One jellyfish, _Dimophyes arctica_, was absent in surface waters but occurred in considerable numbers at depths between 250 and 1200 m. Another species, probably _Botrynema ellinorae_, was found only in the single sample from below 1200 m. Ctenophores (primarily _Beroe cucumis_) occurred sporadically throughout the study area above depths of 1200 m.

TABLE 2.3.8 Average percent of total biomass contributed by selected major groups of zooplankton in Lancaster Sound during 1976 and in eastern Lancaster Sound and western Baffin Bay during 1978.

Location	Lancaster Sound 1976	W Baffin Bay and E Lancaster Sound 1978		
Depth (m)	150 to 0	150 to 0*	50 to 0	150 to 50
Hydrozoa and Ctenophora	2.9	4.4	2.33	5.5
Gastropoda	7.3	1.58	4.6	.07
Copepoda	78.7	84.3	83.59	84.60
Amphipoda	4.8	3.6	4.02	3.43
Chaetognatha	4.0	5.7	4.85	6.09
Larvaceans	1.6	-**	-**	-**

* Depth-weighted average.

** Unweighed in the 1978 study.

Isopods and Ostracods

Isopods and soft-shelled ostracods were not as numerous as other zooplankters but did occur in many samples. Isopods were more common in surface waters, whereas soft-shelled ostracods (not identified as to species but probably *Conchoecia borealis*) became more common below 250 m.

Copepods

At least 57 species of copepods were encountered. Of the major copepod groups, calanoids had the most species (39), followed by cyclopoids (9 species), harpacticoids (eight species) and monstrilloids (one species). This number of species is large relative to other reports from high arctic regions. However, most other studies in the Canadian Arctic have been restricted to surface water sampling, usually not deeper than 50 or 150 m. Deep waters of north Baffin Bay and adjacent areas have seldom been investigated and appear to contain a number of species not found in surface waters.

The majority of the 57 copepod species occurred in low mean densities--less than $0.05/m^3$--and the six most abundant species accounted for over 85% of the total number of copepods present. Four of the six species of numerically dominant copepods occurred in highest densities at relatively shallow depths (Fig. 2.3.9). *Calanus glacialis*, *Pseudocalanus minutus* and *Oithona similis* became progressively less common as depth increased. *Calanus hyperboreus*, although most common from 50 to 0 m, was quite evenly distributed at lower densities from 1200 to 50 m. The two dominant copepods in deeper water were *Metridia longa* and *Microcalanus* spp. Sekerak *et al.* (1976b) also found that *M. longa* was most abundant in deeper water between 250 and 50 m. Due to their small size, early copepodite stages of *Microcalanus* were not assessed quantitatively and are not included in density estimates; *Microcalanus* abundance is, therefore, underestimated. In contrast to other abundant copepods, the density of *Microcalanus* increased with depth. The most abundant copepod was *P. minutus* followed by *O. similis*.

Of the six most abundant copepods, all except *O. similis* were more abundant at inshore stations than in offshore waters of northwest Baffin Bay. Such differences in abundances were significant ($P<0.05$) for *C. hyperboreus*, *C. glacialis* and *P. minutus*. Early copepodite stages of these three species appeared to have a narrower depth range than later copepodite stages and adults, since they were found to be more highly concentrated in the upper 50 m of water. An example of this type of depth distribution is shown in Figure 2.3.10 for *Calanus glacialis*. Sufficient data were collected in 1978 to suggest that the majority of *C. hyperboreus*, *C. glacialis* and *P. minutus* in the study area have a two-year life cycle.

Metridia longa was unusual in that it occurred in highest densities at intermediate depths, and even the young copepodites were most common between 1200 and 250 m rather than near the surface. *Oithona similis* was abundant throughout the study area, and its density in the upper 150 m of water was more than four times higher than that reported for Lancaster Sound in 1976.

Calanus finmarchicus is a north Atlantic species and it is thought that it cannot successfully reproduce in pure arctic water. Early stages of *C. finmarchicus* were found sparsely distributed throughout the study area in the

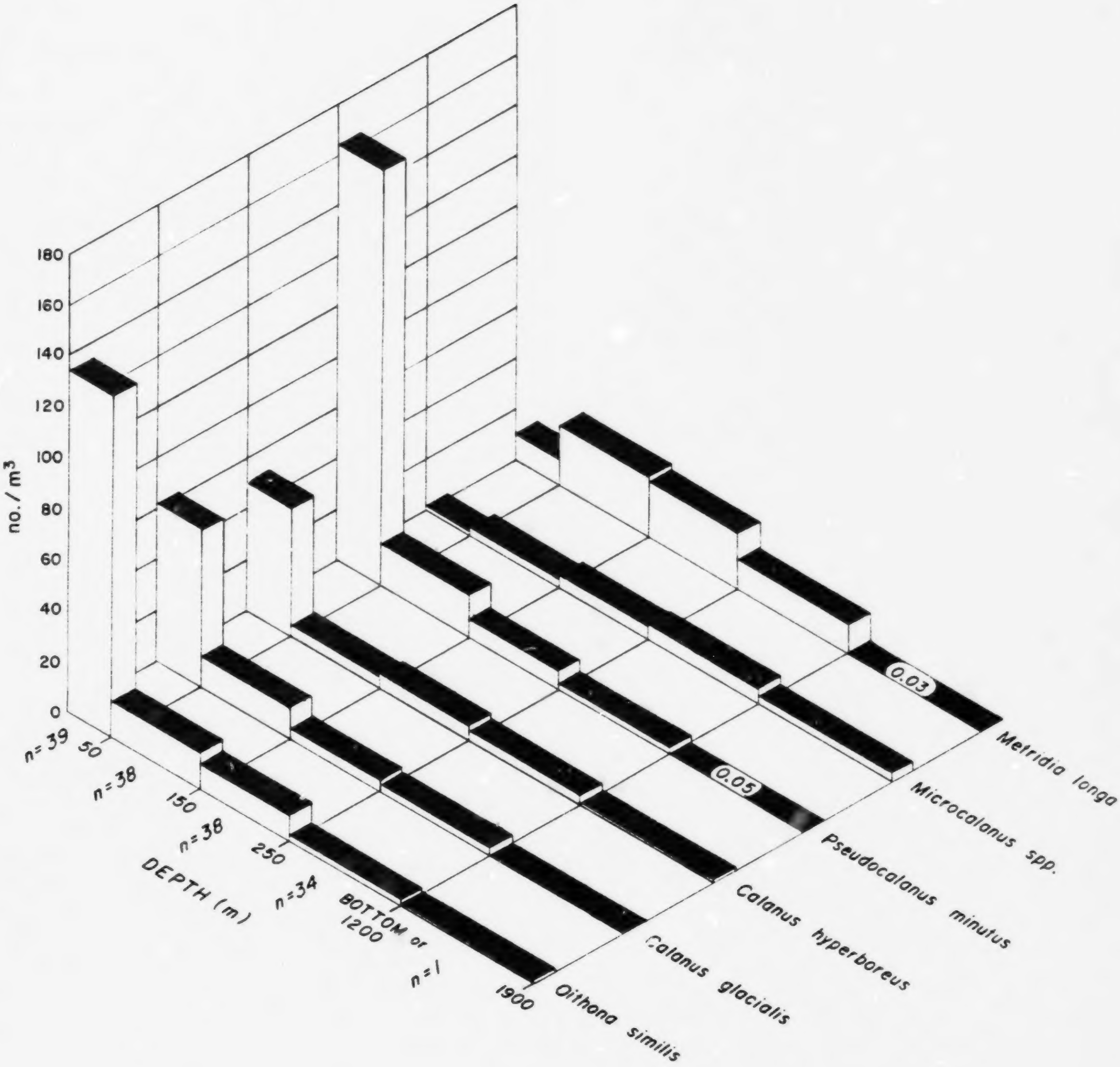


FIG. 2.3.9 Mean density (no./m^3) of the six most common copepods in relation to depth. Copepodites I and II of *Microcalanus* spp. are not included.

	Mean No./m^3				
Depth (m)	50 to 0	150 to 50	250 to 150	Bottom/ 1200 to 250	1900 to 1200
Copepodite					
I	21.28	1.50	0.46	0.02	0
II	9.59	1.84	0.22	0.01	0
III	5.16	0.79	0.13	0.02	0
IV	6.35	0.94	0.32	0.11	0
V	15.24	5.15	2.56	2.07	0
female	3.03	0.98	0.61	0.54	0
male	0.01	0.01	0.02	0.01	0
Total	60.66	11.21	4.32	2.78	0

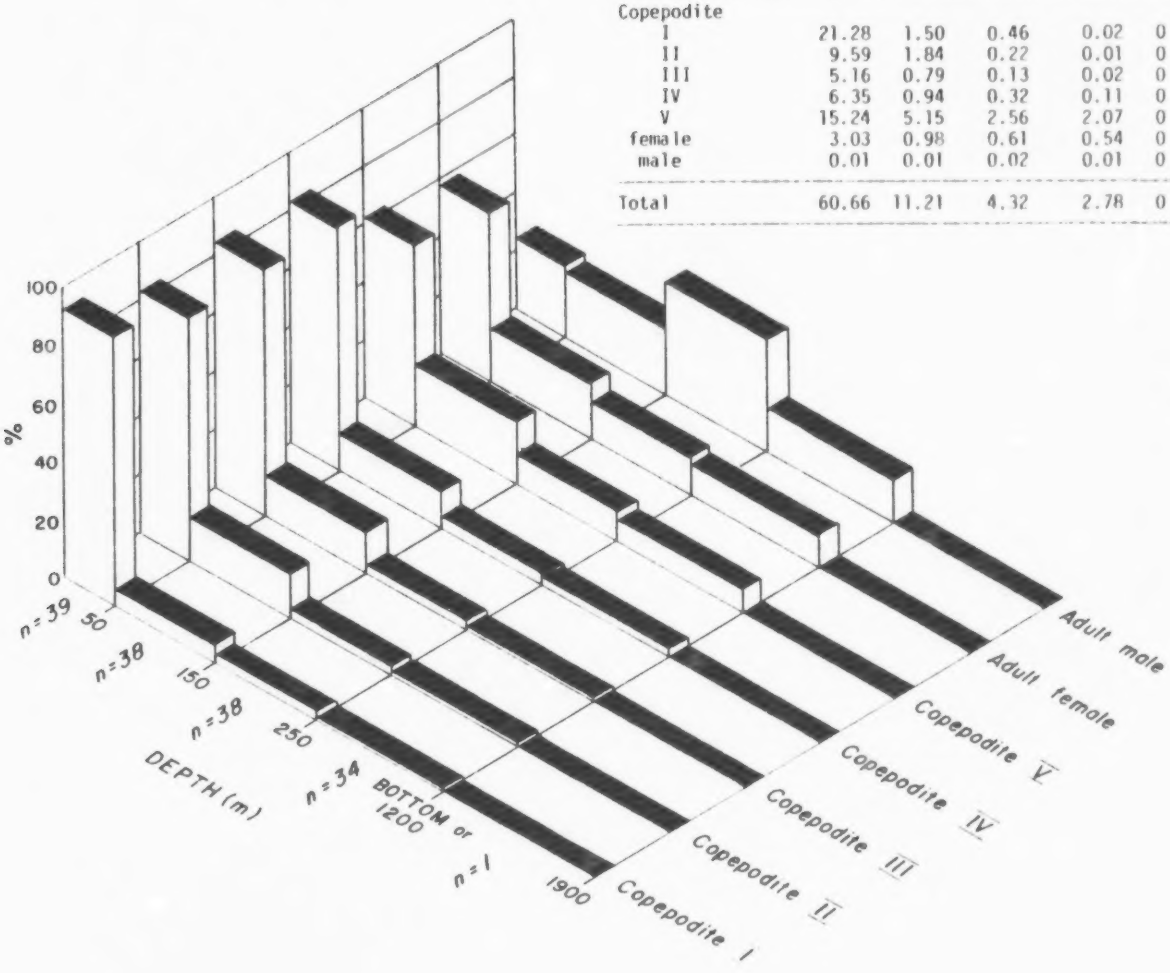


FIG. 2.3.10 Percent of mean total numbers of stages of *Calanus glacialis* in relation to depth.

present study, in Lancaster Sound in 1976 (Sekerak *et al.* 1976b), and in northwest Baffin Bay in the late 1960's by Tidmarsh (1973). In contrast, Grainger (1963) had not found young *C. finmarchicus* in northern Baffin Bay in various collections obtained between 1954 and 1961. The apparent successful breeding of *C. finmarchicus* in northern Baffin Bay and Lancaster Sound in recent times could be related to a change in water circulation, such as a greater penetration of the West Greenland current into Baffin Bay.

The majority of the less abundant copepod species were most often found in deeper waters. Two of the most common ones sampled in 1978 were *Heterostylites major* and *Spinocalanus longicornis*. In contrast to the copepod species that were most common in surface waters, no geographic differences in the abundances of deep water species were evident.

Other Crustaceans

About 15 species of amphipods were recovered; *Parathemisto libellula* and *P. abyssorum* being the most common. The number of amphipod species, like the number of copepod species, increased with depth.

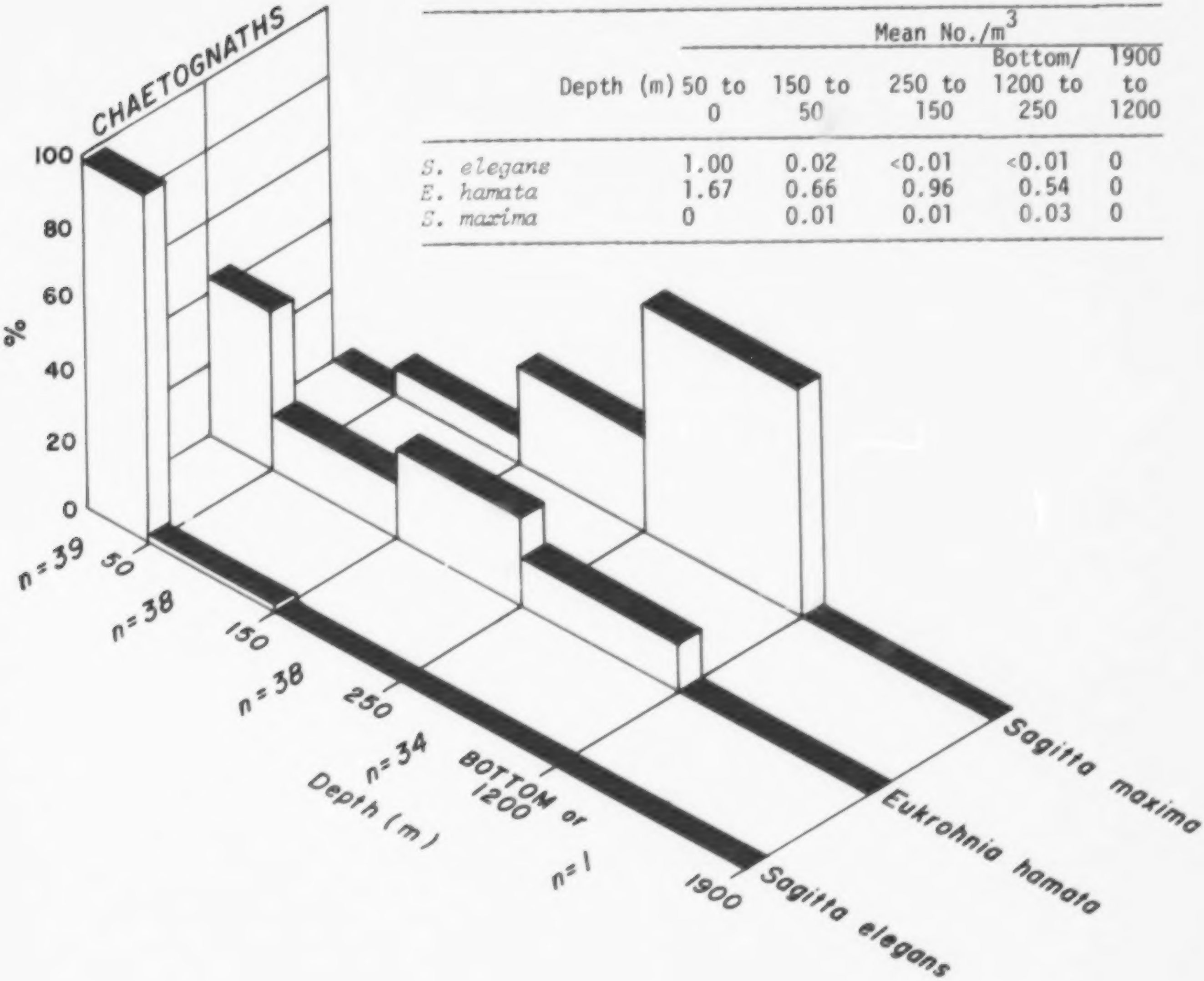
One species of shrimp (*Hymenodora glacialis*) and two mysids (*Boreomysis arctica* and *B. nobilis*) were collected. All were more common in deep water, and *H. glacialis* and *B. nobilis* were found only below 250 m. Because of their large size, shrimp were important in terms of total zooplankton biomass below 250 m.

Chaetognaths

The three species of chaetognaths found in the study area are all common arctic species whose depth distributions are reasonably well known. *Sagitta elegans* was largely restricted to the upper 50 m, *Eukrohnia hamata* was relatively common throughout the water column, and *S. maxima* was common only in deep water (Fig. 2.3.11).

Rare Species

A substantial number of 'rare and unusual' species of zooplankton were found during the present study (Sekerak *et al.* 1979; Shih and Stallard 1982). These included some species outside their previously known ranges, and at least three previously undescribed species. We do not believe that this indicates that the study area is unusual. Rather, it reflects the most intensive sampling effort that has been performed in the region, the sampling of deep water that has rarely been investigated, and a taxonomic effort that was probably greater than in most other environmental baseline studies. Species or stages found by us but not, to the best of our knowledge, previously reported from the study area or adjacent regions include the following copepods: *Spinocalanus horridus*, *Chiridiella reducta*, *Derjuginia tolli*, *Neoscolecithrix farrani*, *Pachyptilus pacificus*, *Haloptilus longicirrus*?, *Mormonilla polaris*, and *Monstrilla longicornis*? (Question marks denote tentative identifications.) In addition, small numbers of the previously undescribed adult male stages of the copepods *Aetideopsis multiserrata* and *A. rostrata* were found. Three copepod species that appear to be new to science were also discovered; two are members of the genera *Oncaea* and *Epicalymma* and one appears to belong to the family Phaennidae.



Depth (m)	Mean No./m³ 50 to 0	150 to 50	250 to 150	Bottom/ 1200 to 250	1900 to 1200
S. elegans	1.00	0.02	<0.01	<0.01	0
E. hamata	1.67	0.66	0.96	0.54	0
S. maxima	0	0.01	0.01	0.03	0

FIG. 2.3.11 Percent of mean total numbers of Chaetognaths in relation to depth.

2.3.2.2 Standing Stock

Mean total numbers and biomass of zooplankton in the study area in 1978 are shown in Table 2.3.9. Larger densities of zooplankton often occur in surface waters, where food for herbivores is abundant. Planktonic larval forms of benthic invertebrates, gastropods, hydrozoans, hard-shelled ostracods, isopods, *Calanus hyperboreus*, *C. glacialis* and especially *Oithona similis* and *Pseudocalanus minutus* were largely responsible for the abundance of zooplankton in surface waters.

Over the entire study period, mean total numbers of zooplankton were greater at inshore than at offshore stations in each depth interval sampled. There were significantly more between 150 to 50 m than between 1200 to 250 m. In addition, inshore areas along southeast Devon Island contained significantly greater densities of zooplankton than offshore areas when depth-weighted means for the entire water column above 1200 m were compared.

Table 2.3.9. Mean total standing crop of zooplankton in eastern Lancaster Sound and northwestern Baffin Bay, 23 July to 30 September 1978.

Depth (m)	No. of samples	Total numbers (no./m^3)	Total biomass (mg/m^3)
50 to 0	39	546	400
150 to 50	38	85	85
250 to 150	38	61	107
1200/bottom to 250	34	37	104
1900 to 1200	1	10	61

Offshore stations also had lower total biomass estimates than stations along southeast Devon Island and Bylot Island; this was true in all depth intervals from 1200 to 50 m, but not 50 to 0 m. However, differences were significant only in one case: southeast Devon Island *vs.* offshore stations in the depth interval 150 to 50 m (see Fig. 2.3.7).

2.3.2.3 Multivariate Comparisons

Factor analysis and discriminant function analysis indicate that depth, date and area are important in determining the abundance and distribution of zooplankton in the study area. Depth appeared to be the most important factor governing general distribution of zooplankton in 1978 (Fig. 2.3.12); however, time (i.e. season) would undoubtedly gain in importance in a study of longer duration. The summer production of zooplankton in surface waters (which is time-related) was an important source of variability in abundance and composition of zooplankton. This variability included increased relative abundances of young stages of zooplankters over time (Factor 1 in Fig. 2.3.12). Factor 2 was also time-related in that it appeared to primarily reflect decreased relative abundance of some common adult copepods over time. These species reproduce in summer and die shortly afterward. Differences in the composition of the zooplankton community were much more closely related to depth than to geographic area; however, area became somewhat important in the upper 50 m of water. It appears that waters from

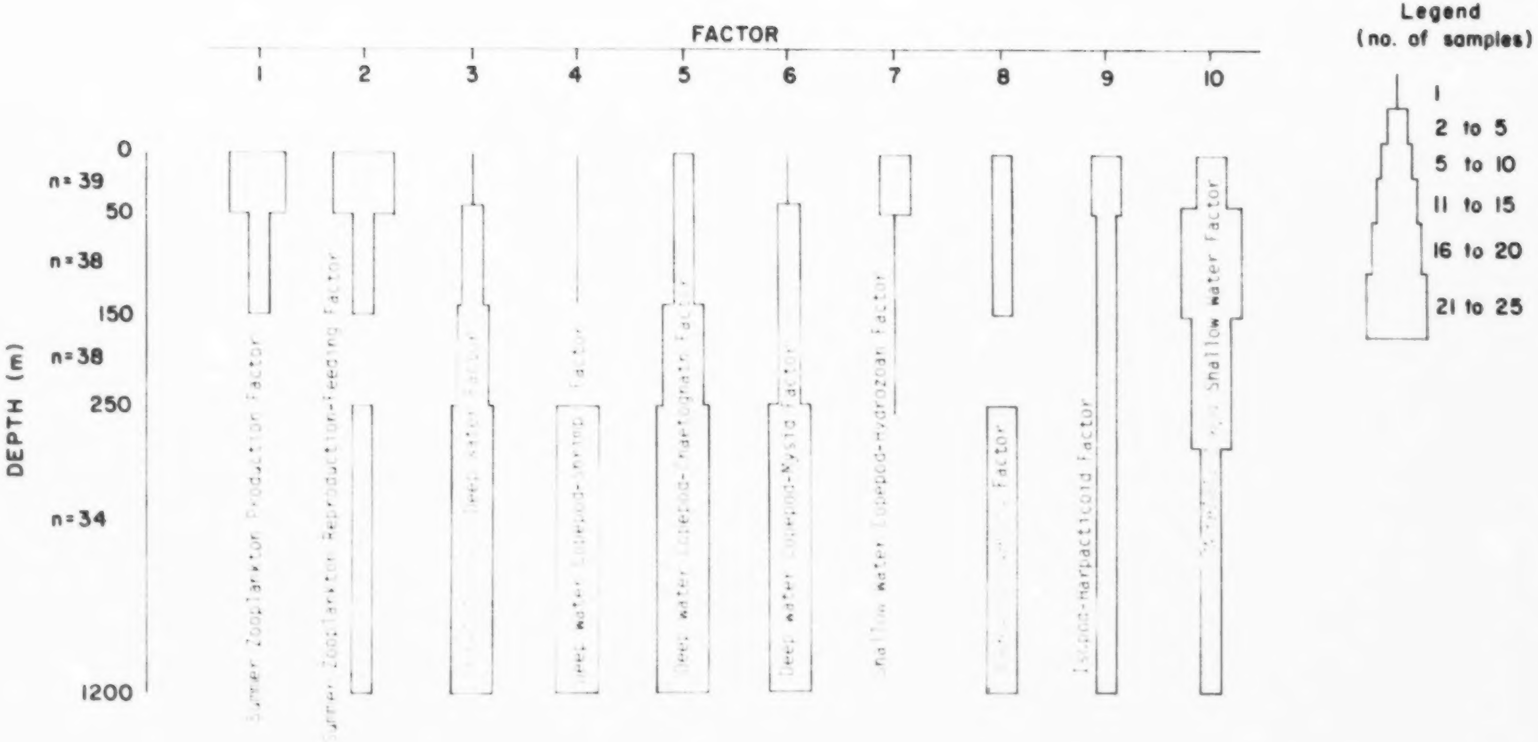


FIG. 2.3.12 Depth distribution of factors 1 to 10 in zooplankton samples from eastern Lancaster Sound and western Baffin Bay in 1978. A factor (species group) was considered to be prominent in a particular sample when the factor score for the sample was >0.5. Width of the bars in the diagram indicate the number of samples in which each factor was present.

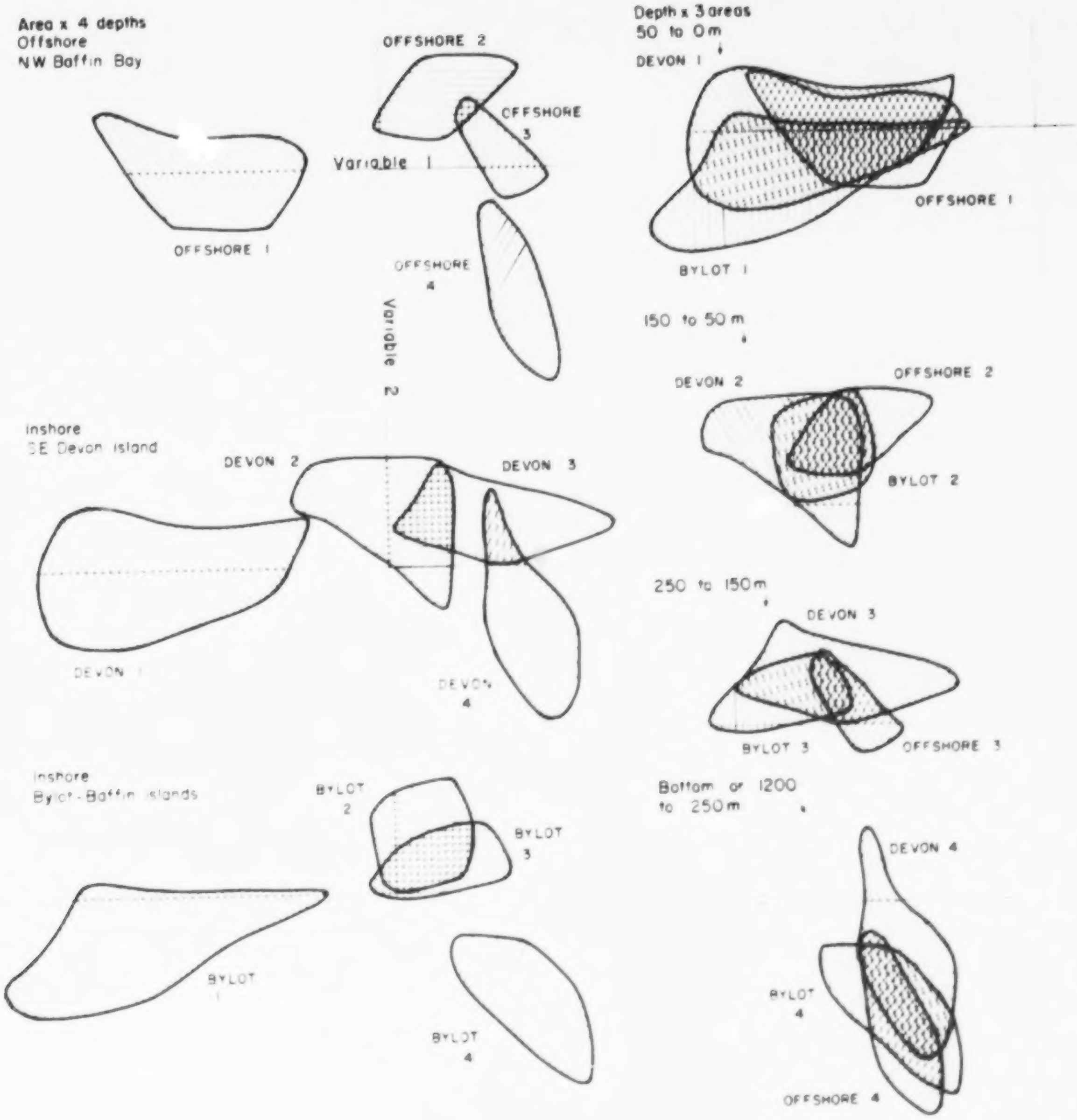


FIG. 2.3.13 Comparisons of zooplankton communities in different areas and depth intervals in eastern Lancaster Sound and western Baffin Bay. For each area, groups 1-4 represent depths 0-50 m, 50-150 m, 150-250 m and 250-1200 m, respectively. Shaded regions represent the space containing all samples from a particular area or depth as indicated by coefficients of the first two canonical variables.

1200 to 250 m and from 250 to 50 m contain assemblages of species that do not vary substantially with area. The assemblage of zooplankters in the upper 50 m is quite different from that found in deeper waters and, in addition, its composition is affected by geographical area. However, geographical area itself is not thought to be a controlling factor. Other variables that can vary with area, such as food availability, temperature and salinity, are likely more influential in determining the composition of the zooplankton community.

Figure 2.3.13 provides information about the influences of depth and area on the zooplankton community of eastern Lancaster Sound and northwest Baffin Bay. As can be seen on the left side of the diagram, surface waters (50 to 0 m) normally contain a distinct zooplankton community. Overlap in community composition and abundance is evident in waters between 250 to 50 m deep but the community below 250 m is again separable from that in shallower waters. In contrast, communities at similar depths in different areas (right side of diagram) exhibit more similarity to one another. In addition, as depth increases envelopes generally become smaller and more overlap is apparent. This suggests that differences in the zooplankton community in different areas become smaller as depth increases (Fig. 2.3.13).

2.3.2.4 Annual and Regional Comparisons

The study in Lancaster Sound in 1976, reported by Sekerak et al. (1976b), and the results of research in 1978 (Sekerak et al. 1979) present opportunities to compare the abundance of zooplankton in different years, since similar methods were used in both studies. Although the study areas overlapped only slightly, three stations were sampled at similar times in both years. To ensure that data from both studies were comparable, 1978 data were depth-weighted down to 150 m and larvaceans were subtracted from total numbers obtained in 1976. All comparisons are restricted to the upper 150 m of water and to samples obtained by vertical tows.

As shown in Table 2.3.10, total numbers of zooplankton in Lancaster Sound in 1976 were significantly greater than those encountered in northwest Baffin Bay-eastern Lancaster Sound in 1978. However, total biomass was similar. When the analysis was restricted to the area sampled in both years, total numbers of zooplankton were also significantly higher in 1976 than in 1978 and total biomass was again similar (Table 2.3.11).

Table 2.3.10. Comparison of zoooplankton abundance (no./m^3) in the upper 150 m of water in Lancaster Sound in 1976 and in eastern Lancaster Sound and western Baffin Bay in 1978.

	Mean	SD	n	Mann-Whitney U Test U	P
Total Numbers					
1976	953	719	30	93	0.001
1978	210	99	30		
Total Biomass					
1976	256	178	30	433	n.s.
1978	220	86	30		
P. minutus					
1976	337	297	18	92	0.001
1978	50	40	30		

The lower total numbers of zooplankton obtained in 1978 were at least partially due to differences in geographical area since, as has been explained, the offshore waters in Baffin Bay often contained a relatively sparse zooplankton community. Real differences in the abundance of zooplankton between years are, however, strongly suggested by the results obtained in east-central Lancaster Sound, north Navy Board Inlet and near Cape Warrender, the areas sampled in both years (Table 2.3.11). As shown in Tables 2.3.10 and 2.3.11, *Pseudocalanus minutus* was significantly more abundant in 1976 than in 1978, both when similar stations and the two overall study areas are compared. Since *P. minutus* was by far the most common zooplankter encountered in both studies, differences in its abundance may largely explain the observed differences in total numbers. Moreover, since it is a small copepod and does not contribute a substantial amount to total biomass, the similarities between total biomass estimates in 1976 and 1978 may be partially explained. Reasons for the differences in total numbers of zooplankton in the two study areas or in similar locations in 1976 and 1978 are unknown, but the especially late break-up of ice in 1978 could be a contributing factor.

Table 2.3.12 gives a more general comparison of zooplankton standing crop among areas of the Canadian Arctic where similar research has been performed. Biomass in the eastern Lancaster Sound-northwest Baffin Bay region is generally substantially higher than has been reported from other regions, although biomass in Brentford Bay, Boothia Peninsula, was about double that found in the present study. Total densities of zooplankton in the 1978 study area approximated those found in most other arctic areas. However, extreme caution should be used in comparisons since most other results are based on a limited number of samples collected within a short period. For example, it is doubtful that a more intensive study would confirm the high total numbers of zooplankton reported to occur in Assistance Bay, Cornwallis Island, and Brentford Bay, Boothia Peninsula.

TABLE 2.3.11 Comparison of zooplankton in the upper 150 m of water at three stations sampled at similar times in 1976[1] and 1978.

Station	Sampling Period	Total Numbers (no./m^3)		*P. minutus* (no./m^3)		Total Biomass (mg/m^3)	
		1976	1978	1976	1978	1976	1978
NB	19-21 Aug.	1987	117	651	6	357	222
	8-12 Sept.	854	308	421	94	91	221
EM	22-28 July	218	250	99	53	208	298
	7-11 Sept.	485	283	258	63	78	158
CW	17-21 Aug.	831	344	191	138	302	201
	7 Sept.	1535	291	1028	81	223	67
Mann-Whitney U		5		1		14	
P		<0.025		<0.005		N.S.	

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[1] Larvaceans excluded from 1976 data.

2.3.3 Ichthyoplankton

Available data on ichthyoplankton in the study area are largely confined to information obtained in 1976 (Sekerak et al. 1976b) and 1978 (Sekerak et al. 1979; Sekerak 1982). In 1978, samples were obtained from horizontally towed Miller samplers at depths of 0, 10, 17, 34, 102 and 170 m at stations shown in Figure 2.3.14. In 1976, 0.5 m diameter plankton nets were towed at depths of 0, 10, 25, 50 and 150 m at six stations in Lancaster Sound.

2.3.3.1 Species Composition

In 1978, ichthyoplankton of the study area consisted of young-of-the-year (Y-O-Y) of six species: arctic cod, gelatinous and Greenland seasnails, dusky snailfish, Atlantic sea poachers and an unidentified sculpin (Table 2.3.13). Arctic cod comprised 87% of the total numbers of ichthyoplankton collected and seasnails comprised 12%. Sea poachers and sculpins were each represented by a single specimen. Sekerak et al. (1976b) found a similar species composition in Lancaster Sound in 1976, although seasnails were not identified to species and Atlantic sea poachers were not collected. Because of their dominance the following discussion is restricted to arctic cod.

2.3.3.2 Distribution and Abundance

In 1978, differences in the abundance of arctic cod were not significantly related to different areas within eastern Lancaster Sound and northwest Baffin Bay, but depth preferences were clearly evident (Fig. 2.3.15). Arctic cod were consistently most abundant at 10 and to a lesser extent 17 m depths and few were captured at the other depths sampled. Arctic cod became noticeably less numerous after mid-August. From late July to mid-August 1978, densities averaged 4.7/100 m^3, whereas from mid-August to mid-September the average density decreased to 2.6/100 m^3. We suspect that in late summer, arctic cod begin to cease their planktonic existence and start to assume a more benthic habit.

Data from vertical tows with 0.5 m diameter plankton nets also indicated that Y-O-Y arctic cod were most common in surface waters (Table 2.3.14). To our knowledge, these are the first data available concerning distribution of Y-O-Y arctic cod throughout the entire water column. They indicate that the Y-O-Y are surface dwellers and are not found in the two deeper water masses in the study area (i.e. below about 250 m).

TABLE 2.3.12 Comparison of density and biomass of zooplankton in eastern Lancaster Sound and western Baffin Bay with other regions in the Canadian Arctic. All data are based on results obtained by similar methods, and with similar net and mesh sites. Numbers of Larvaceans have been deleted in all density data but their biomass remains in estimates of Grainger (1962) and Mohammed and Grainger (1974). Numbers in parentheses denote numbers of samples.

Area	Sampling Period	Total Numbers ($no./m^3$)			Total Biomass (mg/m^3)			Reference
		50 to 0 m	150 to 0 m[3]	1200/bottom[4] to 0 m	50 to 0 m	150 to 0 m	1200/bottom to 0 m	
Entire Study Area	July - September	546 (39)	239	112	399	190	126	Sekerak et al. (1979)
SE Devon Island		656 (14)	298	112	313	172	134	
Bylot-Baffin Island		584 (11)	247	147	422	203	139	
Offshore NW Baffin Bay		356 (14)	181	67	481	196	98	
Lancaster Sound (Larvaceans excluded)	July - September	-	999 (30)	-	-	254	-	Sekerak et al. (1976b)
Foxe Basin-East -West	June - October	- -	- -	- -	29 61	- -	- -	Grainger (1962)
Assistance Bay, Cornwallis Island.[1]	August	1629 (1)	-	-	80	-	-	Mohammed and Grainger (1974)[2]
Slidre Fiord, Ellesmere Island.	August	340 (6)	-	-	82	-	-	Mohammed and Grainger (1974)[2]
Creswell Bay, Somerset Island.[3]	August	1364 (1)	-	-	193	-	-	Mohammed and Grainger (1974)[2]
Bridport Inlet, Melville Island.	August	419 (8)	-	-	154	-	-	Buchanan et al. (1977)
Viscount Melville Sd., near Bridport Inlet		385 (1)	-	-	47	-	-	Buchanan et al. (1977)
Brentford Bay, Boothia Peninsula	September	4560 (2)	-	-	908	-	-	Thomson et al. (1978)

[1] Various depths between 0 and 50 m

[2] Technical report of raw data from which above information was calculated

[3] 33 to 0 m.

[4] Depth-weighted means of combined samples.

TABLE 2.3.13 Species composition and abundance of ichthyoplankton in eastern Lancaster Sound and western Baffin Bay, 1978.

Species		Total		Percent of	
Common Name	Scientific Name	Number Collected	Biomass (mg)	Numbers	Biomass
Arctic cod	*Boreogadus saida* (Lepechin)	254	5336	87.0	61.2
Gelatinous seasnail	*Liparis fabricii* (Krøyer)[1]	33	2395	11.3	27.0
Dusky snailfish	*Liparis gibbus* (Bean)[1]	2	581	0.7	6.5
Greenland seasnail	*Liparis tunicatus* Reinhardtius	1	394	0.3	4.4
Atlantic sea poacher	*Leptagonus decagonus* (Bloch and Schnieder)	1	35	0.3	0.4
Unidentified sculpin		1	42	0.3	0.5

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[1] Reported as *L. koefoedi* and *L. cyclostigma* by Sekerak et al. (1979). Differences are due to recent changes in the taxonomy and nomenclature of snailfish.

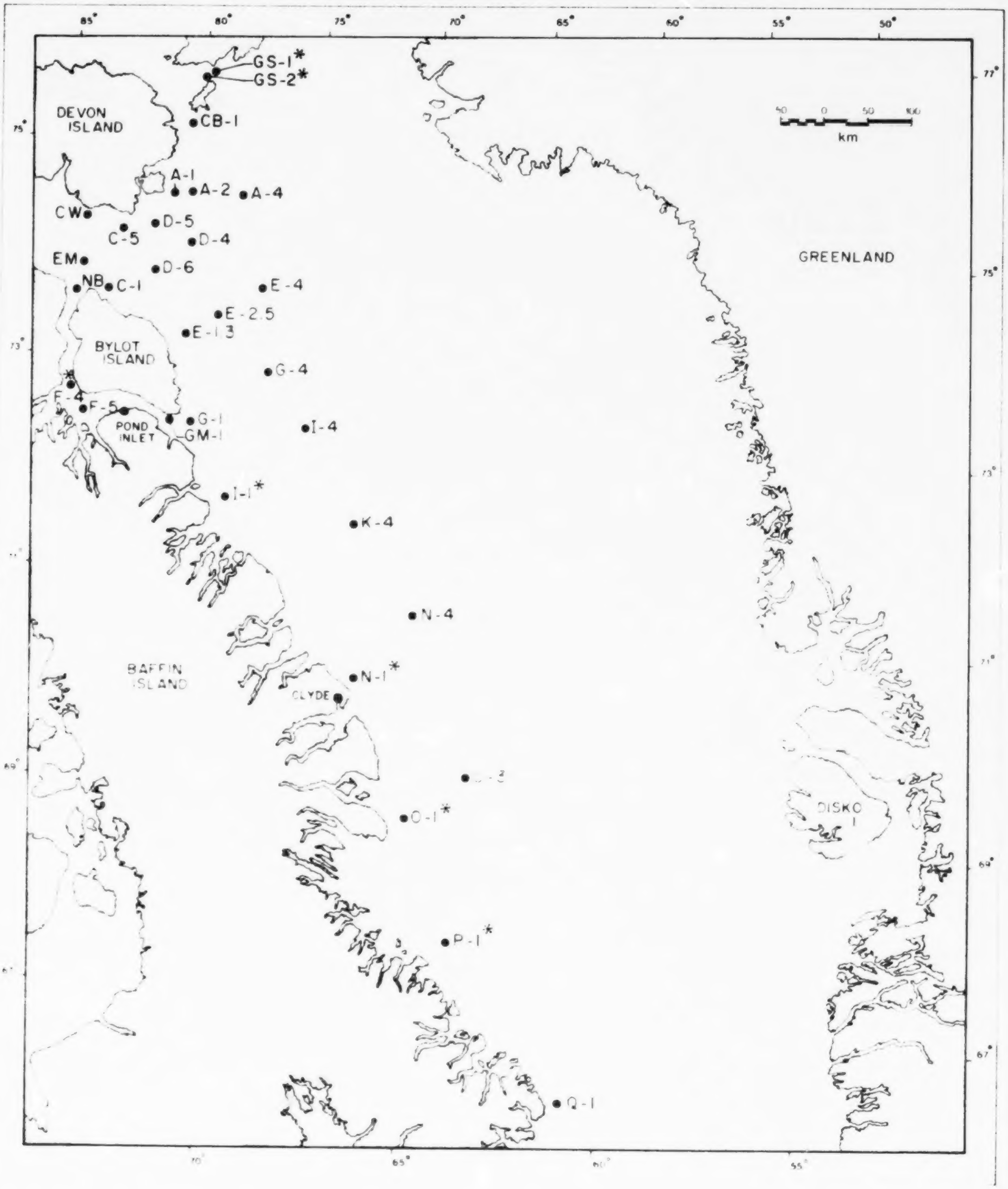
85°
80°
75°
70°
65°
60°
55°
50°
77°
75°
73°
71°
69°
67°
GS-1*
GS-2*
DEVON ISLAND
CB-1
50 0 50 100
km
A-1
A-2
A-4
CW
D-5
C-5
D-4
EM
D-6
GREENLAND
NB
C-1
E-4
E-2.5
E-1.3
BYLOT ISLAND
G-4
F-4
F-5
POND INLET
G-1
GM-1
I-4
I-1*
K-4
N-4
BAFFIN ISLAND
N-1*
CLYDE
O-1*
DISKO I
P-1*
Q-1
70°
65°
60°
55°

FIG. 2.3.11 Ichthyoplankton sampling locations, 23 July to 10 October 1978. Normal sampling consisted of horizontal Miller tows at 0, 10, 17, 34, 102 and 170 m depth. Stations where only 0 and 10 m depths were sampled are indicated by an asterisk.

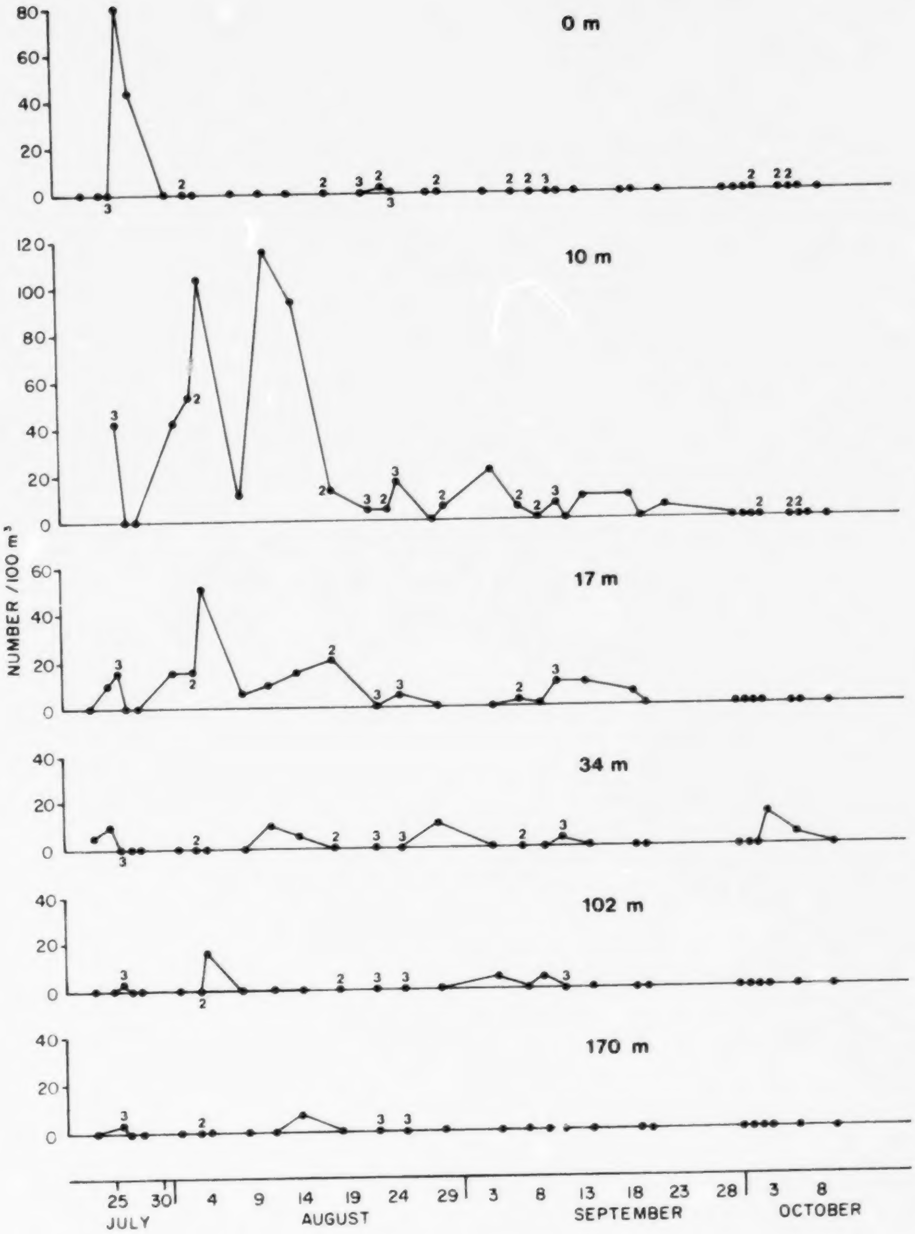

FIG. 2.3.15 Depth distribution of Y-O-Y arctic cod in relation to date, 1978. Each point represents a single sample, except where otherwise indicated.

Table 2.3.14. Number of Y-O-Y arctic cod collected at various depth intervals with 0.5 m diameter vertically towed plankton nets in 1978.

	Depth (m)				
	50 to 0	150 to 50	250 to 150	1200 or bottom to 250	Bottom to 1200 (depth permitting)
No. of Y-O-Y arctic cod	18	0	1	0	0
No. of Samples	43	42	42	39	1
Cod/sample	0.42	0.0	0.02	0.0	-

2.3.3.3 Growth

Mean total length of Y-O-Y arctic cod increased significantly (from nine to 29 mm) over the 76-day study period in 1978 (Fig. 2.3.16). There appeared to be no difference in growth of Y-O-Y cod in offshore versus nearshore waters of the study area. However, Y-O-Y arctic cod were significantly larger in Lancaster Sound in 1976 than in northwest Baffin Bay-eastern Lancaster Sound on corresponding dates in 1978 (Fig. 2.3.17). Since growth was similar within different regions of the 1978 study area, we attribute the differences in size of Y-O-Y arctic cod in 1976 and 1978 to annual variation. Phytoplankton and zooplankton also appeared to be more plentiful in 1976 and differences in growth of cod could be related to food supply.

2.3.3.4 Annual and Regional Comparisons

Y-O-Y cod have been reported from most North American arctic areas where appropriate studies have been performed:

Beaufort Sea, Alaska	- Craig and Griffiths (1978)
Creswell Bay, Somerset Isl.	- Sekerak *et al.* (1976a)
Assistance Bay, Cornwallis Isl.	- Sekerak *et al.* (1976a)
Wellington Channel	- Bain *et al.* (1977)
Lancaster Sound	- Sekerak *et al.* (1976b)
Brentford Bay, Boothia Penin.	- Thomson *et al.* (1978)
Frobisher Bay, Baffin Isl.	- Grainger (1971)
Eastern Chukchi Sea	- Quast (1974)

Because of the variable types of sampling gear used in these studies, the variable depths sampled, and the variable dates of sampling, it is difficult to compare densities of Y-O-Y cod obtained by different investigators working in different regions. Nevertheless, a significant amount of information has been collected in recent years (Table 2.3.15) and the results can be compared in a general way if various biases are kept in mind.

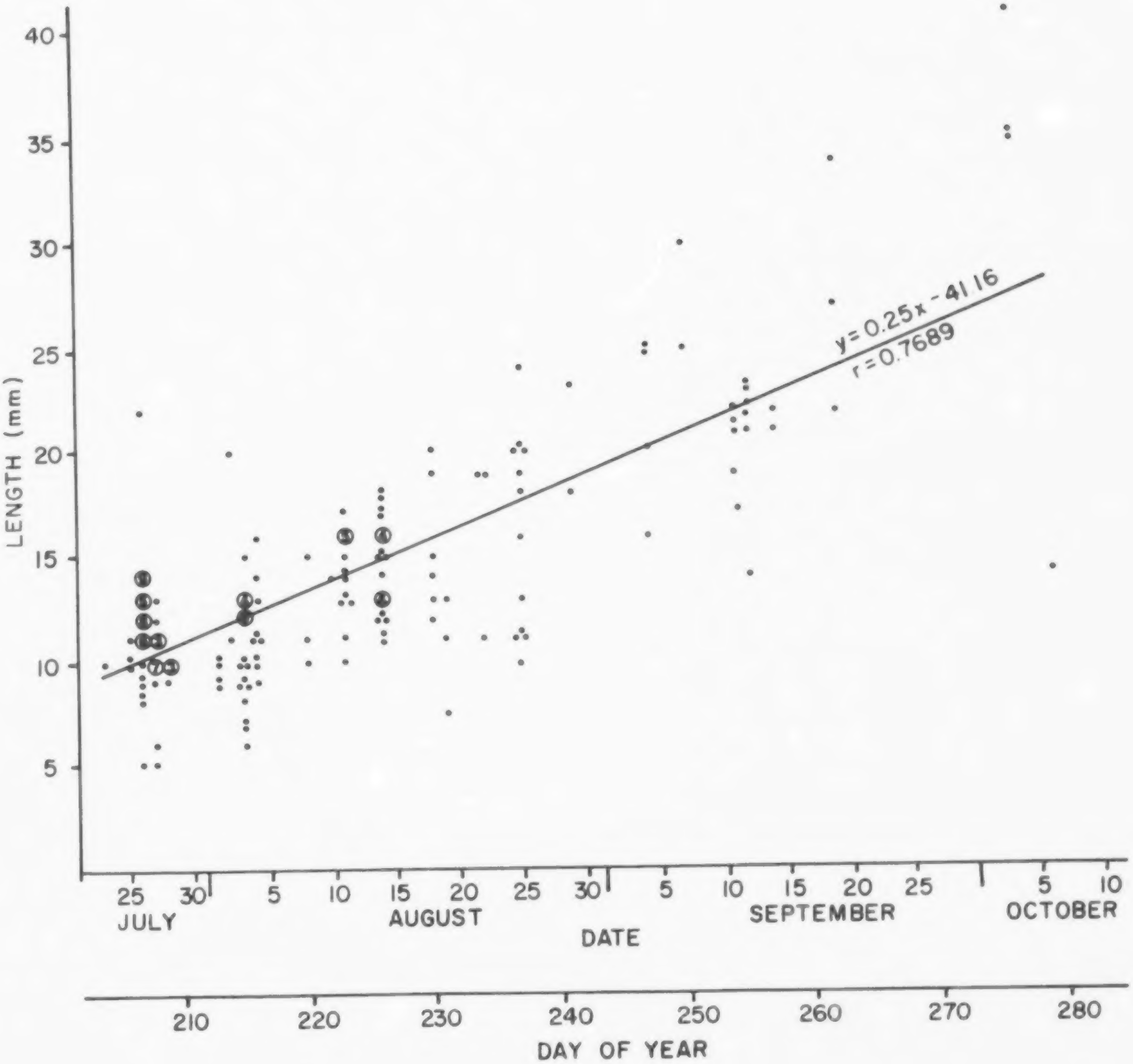

FIG. 2.3.16 Age-length relationship for Y-O-Y arctic cod in eastern Lancaster Sound and western Baffin Bay, 1978.

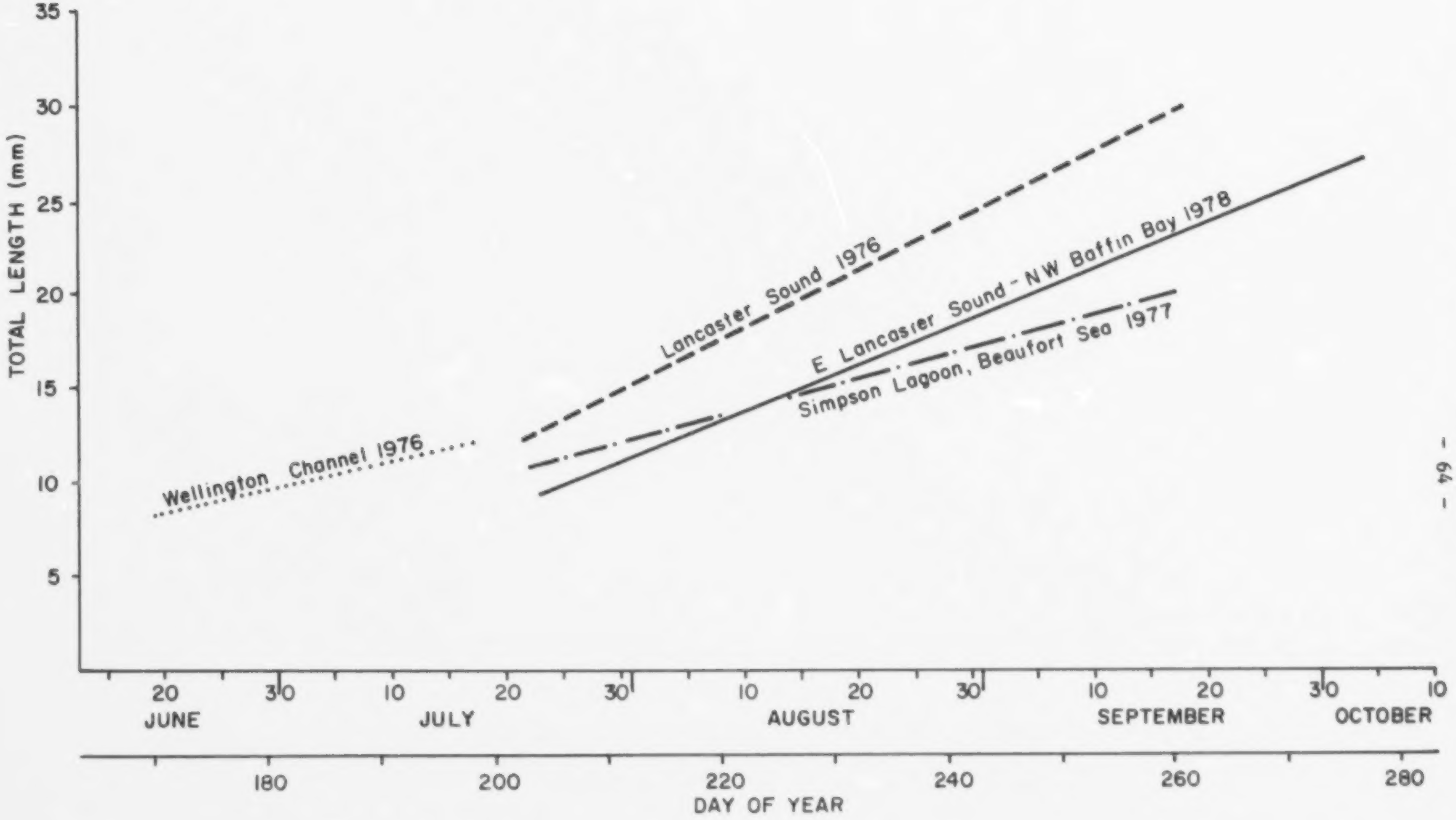

FIG. 2.3.17. Comparison of age-length relationships for Y-O-Y arctic cod. Based on data from Sekerak et al. (1976b, 1979); Bain et al. (1977); and Craig and Haldorson (1981).

Densities of Y-O-Y arctic cod in the 1978 study areas were lower than those in Wellington Channel in June 1976; in the surface waters of Brentford Bay, Boothia Peninsula, in August 1977; and in Lancaster Sound from late July to mid-September 1976 (Table 2.3.15). The higher numbers found in June in Wellington Channel may be misleading since natural mortality could, by August, easily reduce these densities to levels consistent with those found in this study. The high densities reported in Brentford Bay are attributed to an unusual behaviour pattern whereby Y-O-Y cod were highly concentrated at the immediate surface. Densities of Y-O-Y cod in Lancaster Sound in 1976 were slightly higher than in northwest Baffin Bay-eastern Lancaster Sound in 1978. Data are insufficient to clearly distinguish whether such differences are related to geographical areas (the 1976 and 1978 study areas overlapped only slightly) or to annual variations.

2.3.4 Summary

Research in 1976 and 1978 has demonstrated that waters in the northwest Baffin Bay-eastern Lancaster Sound region contain assemblages of planktonic plants and animals that are generally typical of other arctic planktonic communities. Several unusual species of zooplankton were found in 1978, but we do not believe that this indicates that the region is in any way unique. Rather, it indicates the intensive nature of the present baseline collections and the sampling of deep waters that have rarely been investigated.

Several lines of evidence indicate that different regions within the study area are of differential importance to plankton, at least as measured by plankton standing crop. Inshore waters, especially those near southeast Devon Island, generally contained more plankton than offshore waters.

Nutrient concentrations along transects in this region were significantly lower than along transects off northeast Bylot Island during the initial part of the study (late July to mid-August). Young stages of some species of zooplankters, and some kinds of phytoplankters (chrysophytes and centric diatoms), were more common near southeast Devon Island than in other regions of the study area, especially during the early part of the study. The low nutrient concentrations, the presence of large numbers of centric diatoms and zooplankton, and the relatively early appearance of young stages of zooplankton all appear to indicate that the summer bloom of phytoplankton and the summer production of zooplankton were well advanced near southeast Devon Island in comparison to other regions within the study area. The area along southeast Devon Island is commonly ice-free earlier than other adjacent regions. With the disappearance of ice, radical changes in light intensity and quality occur within the water column, and temperature and salinity regimes are also influenced. Such changes might well initiate the summer phytoplankton bloom.

Differences between the plankton communities of Lancaster Sound in 1976 and northwest Baffin Bay-eastern Lancaster Sound in 1978 appeared to exist. However, such differences are difficult to identify with certainty, since the study areas in the two years overlapped only slightly. The 1978 study revealed that offshore waters in northwest Baffin Bay, in comparison with waters closer to shore, generally contained lower densities of zooplankton and lower concentrations of chlorophyll _a_, and sometimes contained lower densities of some groups of phytoplankton. Not surprisingly, when all 1978

TABLE 2.3.15 Average densities (no./100 m^3) of young-of-the-year arctic cod in the North American Arctic. All densities are averages of depth-weighted averages except for Simpson Lagoon. All samplers were towed horizontally.

Area	Depth Range Sampled (m)	Collection Method	No. of Samples	Dates	Density (no./100 m^3)	Reference
Wellington Channel, near Cornwallis Isl.	0 to 25	Miller samplers	72	June 1976	31.0	Bain et al. (1977)
Resolute Passage, near Cornwallis Isl.	0 to 25	Miller samplers	23	early July 1976	2.0	Bain et al. (1977)
Brentford Bay, Boothia Peninsula	1 to 10	Miller samplers	3	30 Aug 1977	242.5	Thomson et al. (1978)
Simpson Lagoon, Beaufort Sea, Alaska	0	Faber net	22	Jul & Aug 1977	8.2	Craig and Griffiths (1978)
			45	Jul & Aug 1978	0.2	Craig and Haldorson (1981)
			14	Sep 1977	0.92	Craig and Griffiths (1978)
			12	Sep 1978	0	Craig and Haldorson (1981)
Eastern Chukchi Sea, Alaska	2 to 45	Isaacs-Kidd mid-water trawl	80	late Sep to mid-Oct 1970	2.8	Quast (1974)
Lancaster Sound	0 to 150	0.5 m plankton nets	92	late Jul to mid-Aug 1976	6.77	Sekerak et al. (1976b)
E Lancaster Sound and NW Baffin Bay	0 to 170	Miller samplers	134	late Jul to mid-Aug 1978	4.66	Sekerak et al. (1979)
Lancaster Sound	0 to 150	0.5 m plankton nets	24	mid-Aug to mid-Sep 1976	3.76	Sekerak et al. (1976b)
E Lancaster Sound and NW Baffin Bay	0 to 170	Miller samplers	101	mid-Aug to mid-Sep 1978	2.65	Sekerak et al. (1979)

data (northwest Baffin Bay and eastern Lancaster Sound) were compared with 1976 data from Lancaster Sound alone (Sekerak et al. 1976b), zooplankton and phytoplankton abundances were found to be lower in 1978. Comparisons of data from three stations common to the 1976 and 1978 studies confirmed that plankton (as measured by chlorophyll a and numbers of zooplankton) was not as abundant in 1978 as in 1976. In addition, young-of-the-year arctic cod appeared to be slightly less numerous in 1978 than in 1976, and at any given date they were significantly shorter in total length in 1978. Therefore, substantial year-to-year variability in the abundance of plankton appears to have occurred, at least in eastern Lancaster Sound where samples were taken at the same stations in two years.

This annual variability greatly complicates comparisons of different geographical areas studied in different years. However, it is still reasonable to suspect that unstudied waters in Lancaster Sound in 1978 supported higher densities of plankton than offshore waters of northwest Baffin Bay in 1978, and that plankton densities throughout Lancaster Sound and northwest Baffin Bay may have been higher in 1976. It should be noted that we are not implying that total annual primary and secondary planktonic production were different in 1976 and 1978. Longer-term studies utilizing different methods would be necessary to address such questions.

2.4 Ice Biota

The soft bottom layer of arctic sea ice in spring supports diverse communities of plants and animals, including microalgae (primarily pennate diatoms), protozoans, nematodes, polychaetes, copepods and amphipods. These communities have only recently been studied in detail, and to date few quantitative studies have been carried out (see Horner 1976, 1977 for a review). In the Baffin Bay-Lancaster Sound area, data are available on species composition and standing stocks of ice algae in Eclipse Sound during May 1976 (Hsiao 1979), and flora and fauna under the Pond Inlet ice edge and adjacent fast ice areas were studied in May-July 1979 (Bradstreet 1980b, 1982a; Bradstreet and Cross 1980, 1982; Cross 1980, 1982). Biota on the undersurface of the outer edge of the pack ice in Davis Strait (60° to 64°N) were studied in April-May 1978 (MacLaren Marex 1979a,b).

Most previous studies of arctic ice biota were carried out in areas of landfast ice during spring (e.g. Horner 1976; Buchanan et al. 1977; Golikov and Averincev 1977; Thomson et al. 1978; Dunbar and Acreman 1980). The only previous studies on pack ice biota in the Arctic, to our knowledge, were near Point Barrow, Alaska, during July-August 1964 (Meguro et al. 1966, 1967). Data on ice algal standing stocks and productivity under pack ice in the western subarctic (Bering Sea) are also available (McRoy et al. 1972; McRoy and Goering 1974; Alexander and Cooney 1979).

2.4.1 Ice Algae

Microalgae in the bottom 10 cm of fast ice in Pond Inlet consisted primarily of pennate diatoms (70.6 to 99.7% of total numbers per sample); most samples were dominated by the species *Nitzschia grunowii* and *N. frigida*. Standing stocks were significantly higher in May (1.3 to 44.1 x 10^6 cells/L) than in June (0.1 to 16.2 x 10^6 cells/L). Similarly, mean concentrations of chlorophyll *a* varied by nearly two orders of magnitude

(10.7 to 913.1 mg/m^3), depending on location and time. The ice algal bloom apparently reached peak development at different times at the three stations studied, probably due to differences in ice and snow cover: at the ice edge and at one fast ice station, chlorophyll *a* concentrations were higher in May, whereas at the other fast ice station, values were higher in June (Cross 1980).

Microalgal communities in the bottom six cm of pack ice in Davis Strait were similar to those from Pond Inlet, both in abundance and in species and group composition. Chlorophyll *a* concentrations, however, were considerably lower than those reported from Pond Inlet. In most samples examined, pennate diatoms comprised 76.7 to 100% of total microalgal numbers, and either *Nitzschia frigida* or *Navicula transitans* was dominant. Standing stocks ranged from 0.36 to 30.37 x 10^6 cells/L. Variability in chlorophyll concentrations was high, both among floes (stations) and among samples within floes. Mean values were low in April, and in May ranged from 0.65 to 41.86 mg chl *a*/m^3. The bloom was apparently almost over in late May (MacLaren Marex 1979a).

At present, there is little evidence of regional variation in composition or abundance of microalgal communities inhabiting arctic sea ice. The highest mean chlorophyll concentration recorded by Cross (1980) for Pond Inlet was considerably higher than any previously reported (e.g. Apollonio 1965; Horner 1976; Dunbar and Acreman 1980). Also, species dominance was less variable among samples from Pond Inlet than elsewhere (e.g. Horner 1977; Hsiao 1979). These differences among studies, however, are likely attributable to localized spatial variability (patchiness) or temporal effects rather than geographical variation. Chlorophyll *a* concentrations in the Davis Strait pack ice were comparable to those from a similar latitude in the Bering Sea ice pack (McRoy and Goering 1974; Alexander and Cooney 1979) but lower than those in pack ice off Barrow, Alaska (Meguro *et al*. 1967). Further data on the flora of arctic pack ice are required, however, to evaluate the regional significance of this difference. Meguro *et al*. (1966, 1967) sampled in late July, a time when ice algae has usually disappeared from the ice.

2.4.2 Primary Productivity

Primary productivity of ice algae was not measured in Pond Inlet, but data are available from C^{14} studies at Barrow, Alaska. Primary productivity of the ice algal layer at Barrow in 1973 decreased from a maximum of 7.67 mg C/m^2/h on 21 May to a low of 0.30 mg C/m^2/h on 8 June (Clasby *et al*. 1973). It was estimated that annual production by ice algae was as much as five g C/m^2, a significant proportion (at least 25 or 30%) of total annual production in coastal regions (Alexander 1974).

Primary productivity rates measured in Davis Strait pack ice (MacLaren Marex 1979b) were very low: all but one measurement were lower than the minimum rate reported for Barrow (see above). Ice algal productivity was also low during March and April in the Bering Sea at 0.18-0.40 mg C/m^2/h (McRoy and Goering 1974). These lower rates in the subarctic may be attributable to lower algal biomass, or to differences in the amount of light reaching the bottom of the ice. Ice algae were estimated to contribute less than one percent to total daily productivity in Davis Strait (MacLaren Marex 1979b).

2.4.3 Invertebrates

Macrofaunal communities on the underice surface in Pond Inlet included nine amphipod and one mysid species, and were dominated by the amphipods *Apherusa glacialis*, *Ischyrocerus anguipes* and *Onisimus* spp. Variability in abundance and biomass was high, both among stations (from 0.1-163.0 individuals/m^2 and from 0.8-619.8 mg/m^2), and among samples within stations. Densities were related to local habitat factors including ice type, fresh water influence and pan ice influence, and significant temporal variablility was also evident. Meiofauna occurring in the bottom layer of ice included nematodes, harpacticoid and cyclopoid copepods, and polychaetes. Total abundance of meiofauna in May at fast ice stations was from 300 to 53,000 individuals/m^2.High meiofaunal densities were associated with high densities of microalgae (Cross 1980).

In Davis Strait, macrofauna collected under pack ice included the amphipods *Onisimus* spp. and *Parapleustes* spp., but due to the collection method, it is not clear whether they were on the ice or in the water immediately below (MacLaren Marex 1979a). Microfauna (ciliates) and meiofauna (nematodes and harpacticoid copepods) were present in relatively few samples of the bottom six cm of ice. In cores where meiofauna were present, their densities were estimated to be up to 320 per litre of melted ice (approximately 27,500 individuals/m^2).

Meiofauna have previously been reported from the bottom layer of ice in other arctic locations (Horner 1976, 1977; Thomson *et al*. 1978). Densities in Brentford Bay, Boothia Peninsula, during May 1977 were similar to those reported from Pond Inlet and Davis Strait, approximately 16,800/m^2 (Thomson *et al*. 1978).

The only previous quantitative data on underice macrofauna are those of Buchanan *et al*. (1977) and Thomson *et al*. (1978). They found underice communities to be dominated by the amphipods *Onisimus* spp. and *Gammarus* spp. at four stations in small, central arctic bays during May and June 1977. Mean abundance and biomass of amphipods in those bays and in Pond Inlet were comparable, but Pond Inlet communities were dominated by *Apherusa glacialis* or *Ischyrocerus anguipes*. Pond Inlet communities were more similar in this respect to the *Apherusa glacialis*-dominated communities reported by Golikov and Scarlato (1973) on the undersurface of pack ice in the Barents Sea. Differences among these studies may be related to ice type or to other habitat, topographic or bathymetric factors, but there is little evidence of geographic variation in the community structure of arctic underice fauna. Too few data are available to evaluate differences between arctic and subarctic ice fauna.

2.4.4 Arctic Cod

Arctic cod (*Boreogadus saida*) have been reported to associate with sea ice (e.g., Andriashev 1970; McAllister 1975), but few data in this regard are available (see Bain and Sekerak 1978). In Pond Inlet, arctic cod were observed in close association with landfast sea ice, both in ice cracks in nearshore areas, and in offshore areas. In the latter case, few cod were observed or collected under smooth ice; higher numbers were observed and collected in traps set beneath rough surface ice. Divers observed concentrations of cod within caverns and crevices between blocks of ice in areas of rafted ice. The fish generally retreated farther into these spaces when disturbed (Bradstreet 1980b). No cod were observed or collected in the pack ice of Davis Strait (MacLaren Marex 1979a). Boreogadus saida is a key link in arctic food webs (Bradstreet and Cross 1980) and will be discussed in more detail in following sections.

2.5 Benthos

Benthic animals live in close association with the sea bottom. Three broad categories of benthic animals can be defined (from Thorson 1957):

1. Infaunal animals live in or on the soft sea bottom. They include burrowers, sedentary animals, and mobile animals that live at the substrate/water interface. The group includes gastropods, urchins, starfish, brittle stars, polychaetes, bivalves and some amphipods.

2. Epifaunal animals live permanently attached to hard substrates and include bryozoans, brachiopods, mussels, anemones, barnacles and hydroids. These animals may be found on rocks, seaweed and other live animals. Most species within this group are filter feeders.

3. Epibenthic animals live in close proximity to the bottom and are active swimmers. Mysids, decapods and some amphipods are included in this group. They may be filter feeders, scavengers or detritivores.

During the EAMES program, benthic surveys were carried out in the nearshore regions of Lancaster Sound and western Baffin Bay from MV Gulf Star in 1978 and from a shore camp on Bylot Island in 1979. Deep water samples were taken in 1978 from MV Theron (Fig. 2.5.1). Infaunal animals were sampled with a grab or a diver-operated airlift. Epibenthic animals were collected with a trawl and by divers. Intertidal animals were taken in quantitative dip net collections. Epifaunal animals were collected or photographed by divers. The results and methods for these surveys are outlined in Thomson and Cross (1980) and Thomson (1982).

The purpose of these studies was to diagnose the species composition of nearshore benthic communities and to relate the distribution and abundance of nearshore benthic organisms to major environmental variables. If these variables could be isolated and their relationships with the biota quantified, some ability to predict biota on the basis of physical attributes could be developed.

2.5.1 General Features of High Arctic Benthos

Although marine life typical of temperate shores, such as barnacles of the genus Balanus and the alga Fucus vesiculosus, are found in the arctic islands, their establishment in the intertidal zone is usually precluded by the lengthy period of fast ice cover and by ice scour during the open-water period. Variations in temperature and salinity may also inhibit algae from inhabiting the intertidal (Lee 1973).

The intertidal zones through much of the arctic islands are cobble beach with some areas of sand, mud and exposed bedrock or boulders (LGL Ltd.,

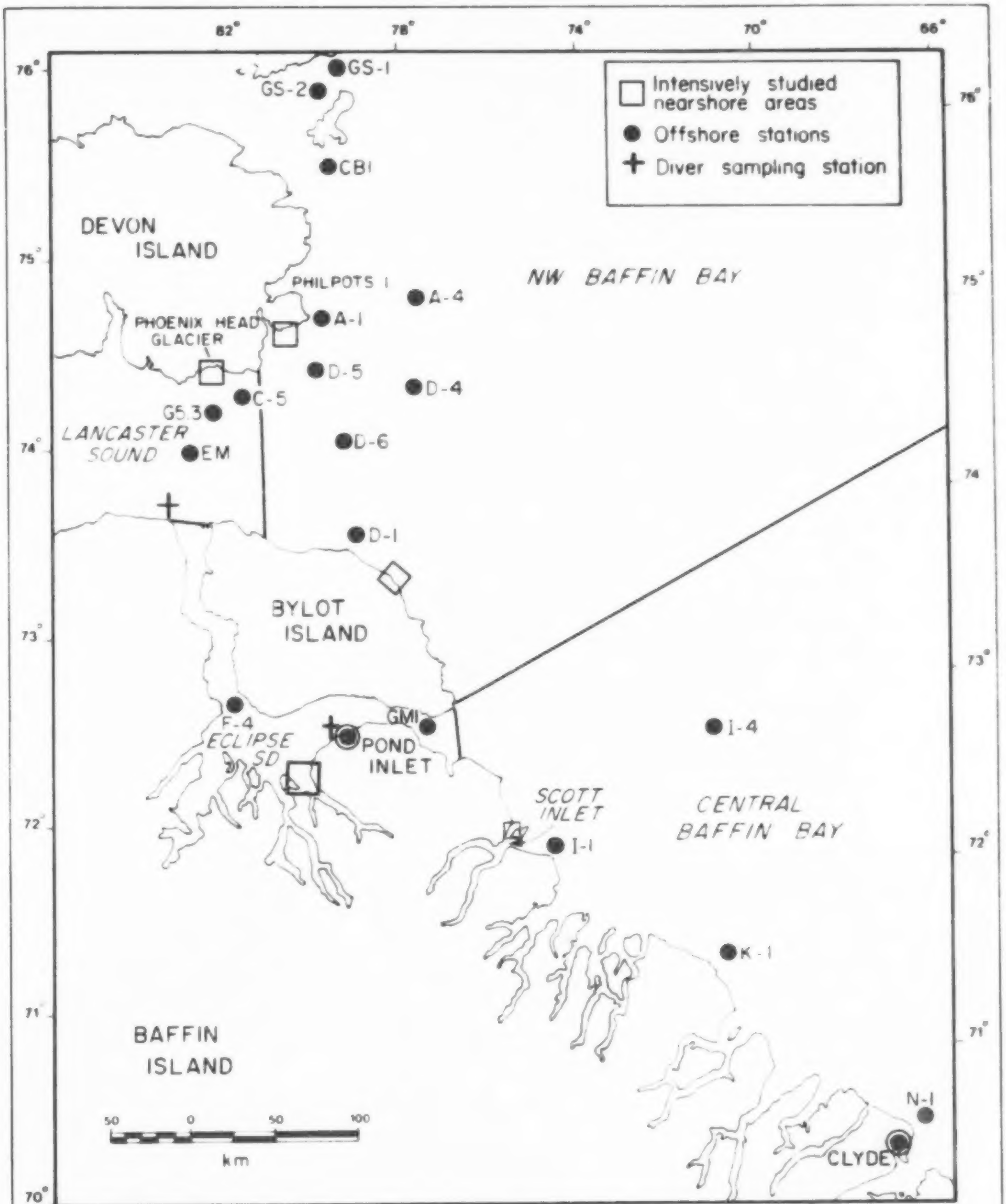
82°
78°
74°
70°
66°
76°
75°
74°
73°
72°
71°
70°
Intensively studied nearshore areas
● Offshore stations
+ Diver sampling station
GS-1
GS-2
CBI
DEVON ISLAND
PHILPOTS I
A-4
A-1
NW BAFFIN BAY
PHOENIX HEAD GLACIER
D-5
D-4
C-5
G5.3
LANCASTER SOUND
EM
D-6
D-1
BYLOT ISLAND
F-4
ECLIPSE SD
GMI
POND INLET
I-4
SCOTT INLET
I-1
CENTRAL BAFFIN BAY
K-1
BAFFIN ISLAND
N-1
CLYDE
50
0
50
100
km

FIG. 2.5.1. Locations of nearshore sampling areas and offshore stations, and the four subdivisions of the study area referred to in the text.

unpubl. data). For most of the year, fast ice is anchored to the shore to a depth of two m or more and occupies virtually the entire intertidal zone. In summer, varying quantities of pan ice may be present in the intertidal. As a result of tidal and current action, these pans abrade the shorelines, and through melting they reduce the surface salinity. Temperatures may reach 5 or 6°C on warm, calm days, but they fall abruptly to 0°C on windy days or in the presence of ice. Salinity of shoreline water is also affected by snow melt and the presence of numerous small streams, many of them ephemeral.

In the arctic, the harsh and variable environmental conditions of intertidal regions appear to have relegated this habitat primarily to mobile, hardy amphipods, especially Gammarus setosus and Onisimus litoralis. Both are found throughout the arctic islands and are almost ubiquitous along many shorelines.

The infralittoral zone is defined as extending seaward from the low tide line. On the Atlantic coast, this zone is characterized by a development of seaweeds, including Laminaria spp.; they may extend above the low water mark (Stephenson and Stephenson 1972). In the high arctic, a barren zone is normally found from the waterline to a depth of two, five m (Ellis 1960; Thomson and Cross 1980). The barren zone is usually marked by the absence of sessile plants and animals, and a sparse infaunal benthos. The cobble substrates typically found on the shoreline usually give way to sand or mud at some point in this zone. Hard substrates in these shallow depths are usually devoid of sessile animal life and may be colonized only by ephemeral algae. Amphipods, mysids, the rockweed Fucus and filamentous algae usually characterize this zone.

The lower limit of the barren zone at a depth of two, five m is usually marked by the appearance of the Laminariales (kelp) and infaunal animals. Depths from there to 50 m, or in some places 100 m, have the highest standing crop.In areas with soft substrates the dominant organisms are bivalve molluscs. Dense kelp forests composed of Laminaria, Agarum and Alaria may be found wherever there is a suitable substrate. Epibenthic mysids and amphipods are also found at these depths but decapods and isopods are also common, especially in the kelp forests. Hard substrates may support dense populations of holothurians, bryozoans, mussels, hydroids and other sessile filter feeders as well as kelps, coralline algae and other algae. Beyond these depths, density and biomass decrease with increasing depth and polychaetes, foraminifera and echinoderms become the dominant life forms.

2.5.2 Infauna

Sediments in the study area tended to be coarser in shallow water than in deeper water (Table 2.5.1) and were significantly coarser in northwest Baffin Bay and finer in Eclipse Sound than in Lancaster Sound or central Baffin Bay (Thomson 1982).

In Lancaster Sound and northwest Baffin Bay, a high standing crop of infaunal animals was found to depths of 50 to 100 m, while in Eclipse Sound a high standing crop was found only to a depth of 25 m (Fig. 2.5.2). In central Baffin Bay, standing crop was low at all depths (Fig. 2.5.2).

Table 2.5.1. Mean grain size ($\bar{\phi}$) and mean sorting coefficient from nine depth intervals in four subdivisions (Fig. 2.5.1) of the study area (from Thomson 1982).

Depth interval (m)	Lancaster Sound		NW Baffin Bay		Eclipse Sound		Central Baffin Bay		All Areas	
	n	$\bar{\phi}$ ± sorting	n	$\bar{\phi}$ ± sorting	n	$\bar{\phi}$ ± sorting	n	$\bar{\phi}$ ± sorting	n	$\bar{\phi}$ ± sorting
5	2	3.0 ± 0.6	2	1.4 ± 0.4	1	1.6 ± 1.3	1	2.9 ± 0.6	6	2.2 ± 0.5
10	2	3.0 ± 1.0	6	2.9 ± 0.4	1	3.7 ± 0.5	1	3.0 ± 0.4	10	3.1 ± 0.8
15–25	7	4.3 ± 2.4	6	3.3 ± 0.9	2	4.3 ± 2.7	2	3.3 ± 1.0	17	3.9 ± 1.7
26–52	3	2.7 ± 1.8	13	3.1 ± 1.1	2	5.4 ± 2.0	7	4.0 ± 2.0	25	3.5 ± 1.4
53–105	6	5.3 ± 2.5	9	3.1 ± 2.0	2	5.3 ± 2.2	11	3.2 ± 2.0	28	3.8 ± 2.2
106–250	4	4.2 ± 2.5	11	3.0 ± 2.1	7	4.4 ± 2.3	8	4.6 ± 2.2	30	3.9 ± 2.2
251–500	1	4.7 ± 2.3	8	5.0 ± 3.0	3	7.5 ± 1.7	1	4.4 ± 2.2	13	5.4 ± 2.6
501–750	7	5.4 ± 0.6	5	5.7 ± 2.6					12	5.5 ± 3.0
751–1100			7	5.0 ± 3.1			3	7.7 ± 2.9	10	5.8 ± 3.1

Beyond the depth of maximum standing crop, there was a continuous and significant decrease in biomass and density with increasing depth (Fig. 2.5.2; Thomson 1982). A decrease in standing crop with increasing depth appears to be a general feature of the world's oceans and is probably related to increasing distance from primary food supplies (see Rowe et al. 1974).

Over all depths, the Lancaster Sound area supported a significantly higher biomass of infaunal animals than did northwest Baffin Bay or Eclipse Sound, both of which supported a higher biomass than central Baffin Bay (Thomson 1982). Thomson (1982) attempted to find other predictors of animal biomass but was unsuccessful because of intercorrelation among variables. For example, grain size of the substrate and organic content of the sediment were correlated with depth and all these variables differed significantly among areas. It was not possible to isolate the effect of any one variable.

Through a factor analysis of the abundances of the 78 most common species, Thomson (1982) identified 24 assemblages of infaunal benthic animals from the study area (Table 2.5.2). Most of these assemblages were found at discrete depths and some were limited in their geographic distribution or substrate preference (Fig. 2.5.3). Thomson (1982) found that depth and geographic location were better predictors of the kinds of animals that would be found in an area than were depth and substrate, but he could not determine how many of these differences in species composition were due to substrate differences among depths and locations.

The first two assemblages found by Thomson (1982) (Table 2.5.2) are similar to the *Macoma* communities found in other arctic regions. The second assemblage (Table 2.5.2), which represents primarily the bivalves *Macoma moesta*, *Astarte borealis*, *A. montagui*, *Mya truncata* and *Serripes groenlandicus*, appears to be a typical high arctic shallow water community (Buchanan *et al*. 1977; Thomson *et al*. 1978). The first assemblage (Table 2.5.2) appears to be a deep water variation of an arctic *Macoma* community (Thomson and Cross 1980).

Current strengths in various parts of the study area may affect standing crop and species composition of benthic animals. A strong current generally enhances the food supply for filter feeders (Olscher and Fedra 1977). The strongest currents found in the study area were over the sampling sites along southern Devon Island in Lancaster Sound, and the lowest were in Eclipse Sound (Fissel *et al*. 1981). Current speeds over sampling sites off Philpots Island in northwest Baffin Bay were weaker than in Lancaster Sound and stronger than in central Baffin Bay (Fissel *et al*. 1981).

The probable importance of food availability as a primary determinant of community composition and standing crop becomes evident when modes of feeding of animals dominating the major assemblages are compared. Table 2.5.3 shows the mean biomass of samples with high scores for various factors, and the mode of feeding of the species most characteristic of each of these factors. All but one of the assemblages that included suspension feeders were most prominent at sites in northern Baffin Bay, Lancaster Sound, and shallow water in Eclipse Sound. Samples in which these assemblages were prominent tended to have high biomass. The only assemblage that included suspension feeders and a low biomass (factor 17) was most prominent in central Baffin Bay and deep water in Eclipse Sound. Assemblages that were characteristic of Scott

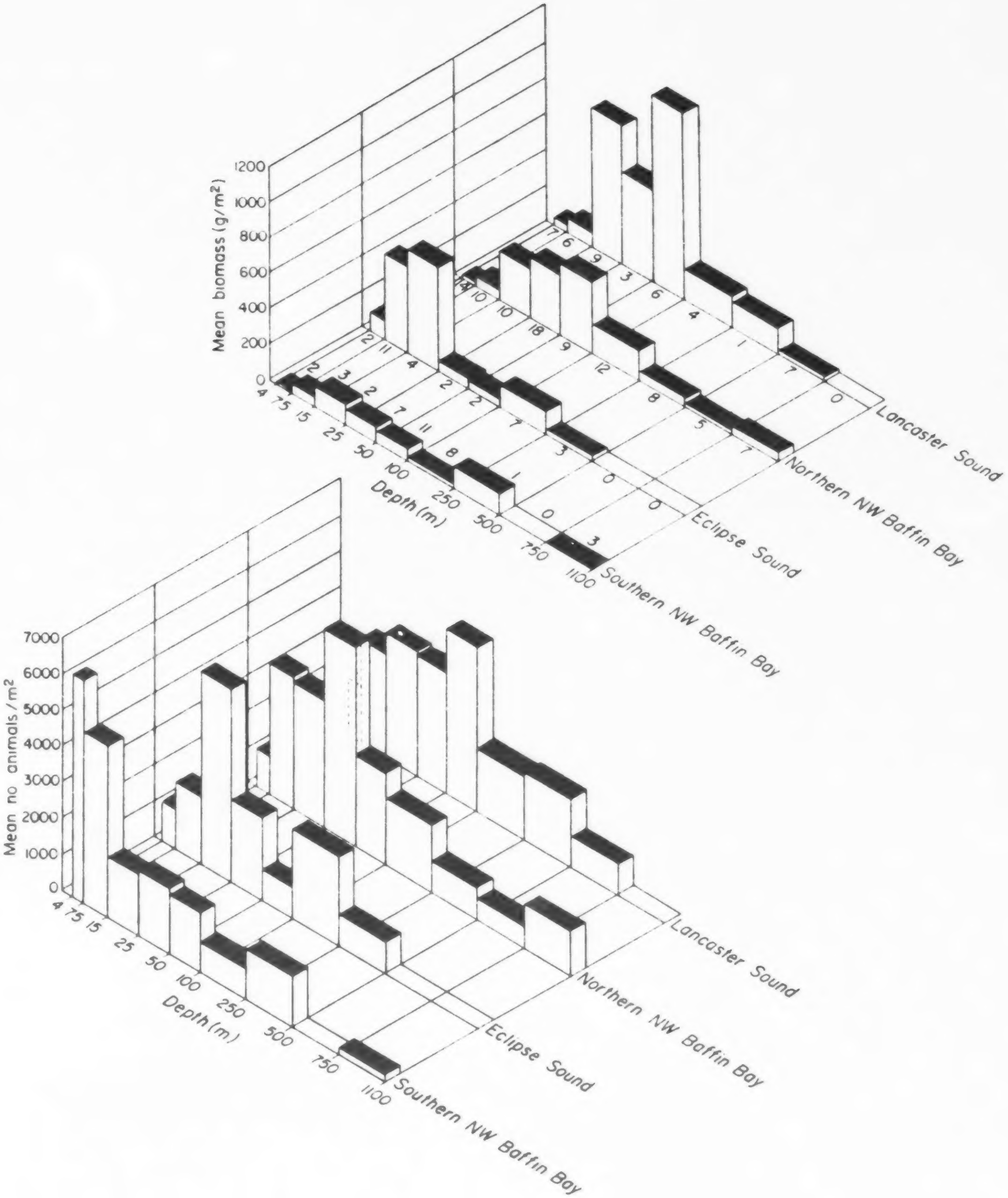

FIG. 2.5.2 Depth distribution of the standing crop of benthic animals taken in eastern Lancaster Sound and western Baffin Bay. Each value plotted is the mean biomass or density in all samples collected within the indicated depth ranges. Blanks are depths not sampled. The number of samples taken at each depth interval and area is also shown. From Thomson and Cross (1980).

Table 2.5.2. Results of a factor analysis of the 78 most abundant benthic animals taken by grab and airlift in western Baffin Bay and Lancaster Sound in 1978 and 1979. The values shown are the correlations between the log-transformed abundances of various species (the original variables) and each of the 24 factors determined in the analysis. Species whose abundances were weakly correlated with a factor ($-0.4 < r < 0.4$) are not shown. Each factor is assigned a name (beside number) indicating some or all of the main type(s) of animals represented (from Thomson 1982).

1. *Macoma* - *Astarte*	
Ophiura robusta	0.853
Lepeta caeca	0.789
Macoma calcarea	0.758
Brachydiastylis resima	0.727
Strongylocentrotus droebachiensis	0.703
Margarites spp.	0.694
Astarte montagui	0.687
Hiatella arctica	0.606
Ophiocten sericeum	0.512
Glycera capitata	0.481
Ostracoda	0.495

2. *Astarte borealis*	
Astarte montagui	0.432
Macoma moesta	0.814
Guernea sp.	0.773
Astarte borealis	0.721
Serripes groenlandicus	0.649
Mya truncata	0.567
Phloe minuta	0.536
Musculus niger	0.520
Cistenides granulata	0.441
Ophilina aulogaster	0.472
Scoloplos armiger	0.474

3. Owenids	
Ophiocten sericeum	0.424
Myriochele oculata	0.833
Myriochele heeri	0.786
Dacrydeum vitreum	0.737
Nephtys ciliata	0.560
Maldane sarsi	0.555
Foraminifera	0.548
Prionospio spp.	0.401
Cistenides hyperborea	0.499
Ophiura sarsi	0.412
Ostracoda	0.488

4. *Praxillura* - *Golfingia*	
Paraxillura spp.	0.812
Golfingia margaritacea	0.699
Prionospio spp.	0.610
Glycera capitata	0.572
Onuphis conchylega	0.525
Asychis biceps	0.418
Ophiacantha bidentata	0.410

Table 2.5.2 Continued

5. Anonyx - Caprella

Anonyx sarsi	0.768
Caprella septentrionalis	0.659
Anonyx nugax	0.622
Marenzelleria wireni	0.570
Paroediceros lynceus	0.568
Atylus carinatus	0.508

6. Travesia forbesi

Anonyx laticoxae	0.812
Travesia forbesi	0.778
Monoculopsis longicornis	0.737
Lamprops fuscata	0.485

7. Owenia - Diastylis

Owenia fusiformis	0.786
Diastylis rathkei	0.752
Pelonaia corrugata	0.645

8. Protomedia fasciata

Protomedia fasciata	0.775
Rhizomolgula globularis	0.730
Capitella capitata	0.590
Chaetozone setosa	0.523
Lamprops fuscata	0.442

9. Aglaophamus - Asychis

Aglaophamus malmgreni	0.821
Asychis biceps	0.707
Sipunculids	0.528
Spiochaetopterus typicus	0.444

10. Cistenides

Cistenides granulata	0.670
Cistenides hyperborea	0.538
Atylus carinatus	0.523

11. Ampeliscids

Ampelisca escherichti	0.835
Byblis gaimardi	0.655
Scalibregma inflatum	0.413

12. Pelonaia - Mesidotea

Pelonaia corrugata	0.447
Thracia sp.	0.775
Mesidotea sabini	0.752

13. Lumbrineris - Ascidia

Lumbrineris fragilis	0.774
Ascidia callosa	0.744

14. Apherusa megalops

Apherusa megalops	0.783
Musculus discors	0.510

Table 2.5.2 Continued

15. *Samythella*

Samythella neglecta	0.750
Thelepus cincinnatus	0.651
Ophiacantha bidentata	0.428

16. *Pontoporeia* - *Onisimus*

Pontoporeia affinis	0.901
Onisimus litoralis	0.682

17. *Bathyarca* - *Praxillella*

Bathyarca raridentata	0.781
Praxillella gracilis	0.771

18. *Ophiura sarsi*

Ophiura sarsi	0.652
Terebellides stroemi	-0.416

19. *Musculus*

Musculus discors	0.441
Musculus niger	0.479
Scalibregma inflatum	-0.558

20. *Brada inhabilis*

Brada inhabilis	0.691

21. *Nereis zonata*

Nereis zonata	0.862

22. *Polyphysia crassa*

Polyphysia crassa	0.907
Spiochaetopterus typicus	0.568

23. *Ctenodiscus*

Ctenodiscus crispatus	0.849

24. *Anonyx pacificus*

Anonyx pacificus	0.864

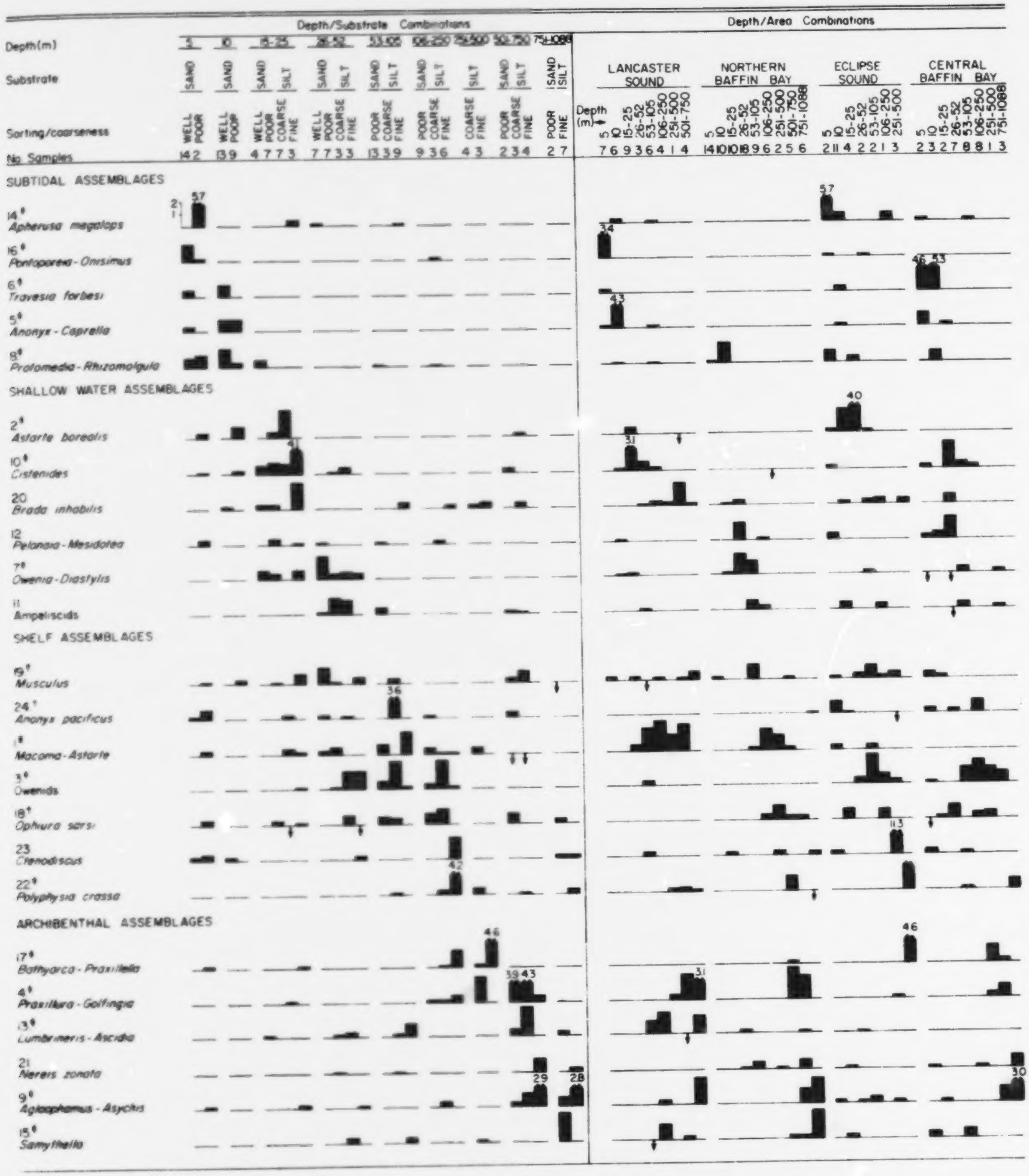

FIG. 2.5.3 Mean factor scores for various depth/substrate and depth/area combinations in eastern Lancaster Sound and western Baffin Bay. Values >0.1 are denoted by a bar and values <-0.1 are denoted by ↓. From Thomson and Cross (1980).

Table 2.5.3. Mean biomass of samples with factor scores >1.0 for the indicated factors (from Table 2.5.2 and Fig. 2.5.3). Only factors with high scores at depths >15 m are considered. The locations from which most of these samples were taken and the feeding modes of the species most characteristic of each factor are also shown. SF = suspension feeder, DF = deposit feeder (from Thomson 1982).

Factor	Name	No. of samples	Biomass mean ± SD	Feeding mode^a	Location
<250 m					
10.	Cistenides	17	633 ± 542	DF	Lancaster Sound/Scott Inlet/Eclipse Sound (shallow)
1.	Macoma - Astarte	30	529 ± 350	DF/SF	Lancaster Sound/Philpots Island
2.	Astarte borealis	14	516 ± 370	DF/SF	Eclipse Sound (shallow)
19.	Musculus	18	502 ± 348	SF	Philpots Island/Lancaster Sound/Eclipse Sound (shallow) Bylot Island/Philpots Island
7.	Owenia - Diastylis	25	379 ± 415	SF/DF	Bylot Island
3.	Owenids	21	99 ± 139	DF	Scott Inlet/Eclipse Sound (deep)
13.	Lumbrineris - Ascidia	3	733 ± 778	DF/SF	Lancaster Sound
>250 m					
23.	Ctenodiscus	3	25 ± 5	DF	Eclipse Sound
9.	Aglaophamus - Asychis	16	61 ± 97	DF	All deep water except Eclipse Sound
4.	Praxillura - Golfingia	14	160 ± 216	DF	Lancaster Sound/northwest Baffin Bay
15.	Samythella	7	27 ± 10	DF	Lancaster Sound/northwest Baffin Bay
22.	Polyphysia crassa	5	26 ± 21	DF	Eclipse Sound/northwest Baffin Bay
17.	Bathyarca - Praxillella	7	17 ± 13	SF/DF	Eclipse Sound/central Baffin Bay

Inlet and deeper areas in Eclipse Sound included only deposit feeding species and were mostly prominent in samples with low biomass.

Thomson (1982) postulated the following relationships to explain areal differences in biomass and species composition in the study area. At depths of 15 - 250 m in Lancaster Sound, high biomass and communities including filter feeders may be maintained to considerable depths by high current speeds (Fissel et al. 1981), and possibly by high primary productivity. Currents are somewhat less strong in northwest Baffin Bay and biomass is lower there than in Lancaster Sound. Community composition is similar in Lancaster Sound and northwest Baffin Bay, and such differences as do exist may be due to substrate (Thomson 1982). Weaker currents in Eclipse Sound and central Baffin Bay may lead to the observed low biomass and dominance by deposit feeders. High biomass and dominance of filter feeders in the shallow areas of Eclipse Sound indicate that productivity in this area may be high.

2.5.3 Epifaunal Animals

The fauna and flora of rock substrates were investigated at four locations within the study area (Thomson and Cross 1980). Epifaunal animals are not the sole inhabitants of these substrates and in some places they may be absent or take second place to motile forms. The foliose, filamentous, crustose and coralline algae that extensively colonize vertical rock surfaces provide a habitat for many species of fish and invertebrates including some normally infaunal forms. The limpet Acmaea testudinalis, the chitons Tonicella marmorea and Lophyrochiton albus, the sea stars Leptasterias polaris, Solaster papposus and others, the urchin Strongylocentrotus droebachiensis and gastropods are motile forms commonly encountered on these rock surfaces.

Attached sessile animals were common on a vertical rock face in Clarke Fiord. Thomson and Cross (1980) found numerous small barnacles at depths between four and 10 m. The bivalves Hiatella arctica and Musculus discors were apparent from a depth of two m to 10 m. Unidentified green sea anemones were found in crevices and on exposed rock surfaces below seven m. Several specimens of H. arctica were commonly attached to the base of the column of these anemones. A group of 12 or more small orange anemones was found on the underside of a small rock ledge at a depth of about eight m. Unidentified encrusting sponges, both purple and yellow, first became evident at six m. Sea cucumbers (Psolus sp.) were found attached to the rock wall, normally in groups of three or four, at depths of eight m or more. A single specimen of the ascidian Ascidia callosa was noted at a depth of about eight m. Spirorbid polychaetes were common on both coralline algae and Desmarestia aculeata.

Very few of these habitats have been investigated previously in the high arctic, but the observations of Thomson and Cross (1980) and LGL Ltd. (unpubl. data) indicate that the faunal composition of the rock face described above is not unique. Quantitative studies of epifauna have not been carried out in the study area, but on the Labrador Coast, biomass of epifauna was four times higher than that of the infauna found at the same four locations (Barrie et al. 1980). Curtis (1975) points out that many records of very high benthic biomass in the Arctic are due to the presence of epifaunal forms.

2.5.4 Epibenthic Animals

Amphipods were the dominant animals encountered in the intertidal zone of Lancaster Sound and northwest Baffin Bay (Table 2.5.4). As in other parts of the arctic islands, *Gammarus setosus* and *Onisimus litoralis* accounted for most of the specimens collected (Table 2.5.4).

Thomson and Cross (1980) found that high densities of *Gammarus setosus* were associated with the presence of large rocks, low tide, low salinity and a gentle slope in the intertidal zone. High densities of *Onisimus litoralis* were associated with sand and pebble substrates and low tide. These two species have distinct habitat preferences and probably very dissimilar feeding habits (see Section 4.0: Trophic Relationships). The relationship between high densities of *O. litoralis* and low water, and the occurrence of highest densities of this species below the intertidal (Tables 2.5.5 and 2.5.6) indicate that it is not a truly intertidal species in the study area. *Gammarus setosus*, on the other hand, was most abundant in the intertidal (Table 2.5.5). The density at five m was low in all areas except Cape Fanshawe where ice along the shoreline covered the intertidal zone and forced the amphipods to a deeper depth. Thomson and Cross (1980) concluded that it is the lack of algae and damp refuges that prevents amphipods from remaining in the intertidal at low water.

Table 2.5.4. Mean biomass (g/m^2) and abundance (no./m^2) of animals taken in the intertidal zone of five areas in eastern Lancaster Sound and Eclipse Sound. P means present but biomass was less than 0.01 g/m^2. Values listed are means ± SD.

Species	Philpots Island (13)	Phoenix Head Glacier (25)	Croker Bay (8)	Navy Board Inlet (14)	Eclipse Sound (23)
Biomass (g/m^2)					
Gammarus setosus	0.21 ± 0.43	7.98 ± 23.52	0.04 ± 0.05	0	1.06 ± 1.88
Onisimus litoralis	0.26 ± 0.52	0.26 ± 0.37	0.01 ± 0.01	0.05 ± 0.07	0.15 ± 0.43
Other Amphipods	0	0.03 ± 0.08	0.02 ± 0.05	0	0.01 ± 0.03
Total Amphipods	0.46 ± 0.86	8.18 ± 23.52	0.07 ± 0.08	0.05 ± 0.07	1.21 ± 1.97
Copepods	P	0	P	0.01 ± 0.01	0.02 ± 0.01
Other Animals	0	P	0	0	0.16 ± 0.50
Total	0.46 ± 0.86	8.18 ± 23.52	0.07 ± 0.07	0.06 ± 0.08	1.40 ± 2.13
Abundance (no./m^2)					
Gammarus setosus	6 ± 10	427 ± 880	22 ± 26	0	113 ± 179
Onisimus litoralis	25 ± 53	5 ± 8	1 ± 2	3 ± 3	9 ± 15
Other Amphipods	0	1 ± 1	1 ± 1	0	2 ± 6
Total Amphipods	32 ± 65	433 ± 883	24 ± 26	3 ± 3	125 ± 191
Calanoids	1 ± 1	1 ± 1	1 ± 1	7 ± 8	1 ± 2
Cyclopoids	0	1 ± 2	0	0	17 ± 51
Harpacticoids	0	2 ± 8	2 ± 4	1 ± 1	398 ± 766
Total Copepods	1 ± 1	3 ± 10	3 ± 4	7 ± 8	416 ± 804
Other Animals	0	1 ± 1	0	1 ± 2	94 ± 128
Total	32 ± 65	436 ± 889	27 ± 30	10 ± 10	635 ± 907

Table 2.5.5. Mean density (no./m^2 ± SD) of two amphipod species in the littoral of eastern Lancaster Sound and western Baffin Bay.

Area -	All Areas		Cape Fanshawe	
Depth -	Intertidal	5 m	2 m	5 m
Collection Method -	Dip Net	Grab	Drop Net	Drop Net
No. Samples -	(83)	(25)	(5)	(5)
Gammarus setosus	163 ± 517	116 ± 279	1762 ± 1045	123 ± 1167
Onisimus litoralis	9 ± 23	117 ± 320	1656 ± 1068	111 ± 1165

The amphipod *Onisimus litoralis* and mysids, especially *Mysis oculata* and *M. litoralis*, are the most conspicuous animals encountered in the 'barren' zone. *Onisimus litoralis* is often observed swimming above the bottom at these depths and in some locations mysids may form dense swarms along the shoreline (Thomson *et al*. 1978; LGL Ltd., unpubl. data). A barren zone teeming with epibenthic animals has been observed in certain very protected places in Brentford Bay and Bellot Strait (Boothia Peninsula) and at Brooman Point along Bathurst Island. Divers did not observe such prodigious numbers of epibenthic animals in the barren zone during EAMES surveys; however, drop net samples taken along the exposed coast off Bylot Island recovered more than 1000 amphipods/m^2 (Table 2.5.5). In deeper water, mysids may form dense concentrations under the fronds of kelp or form dense swarms just above the sea bed (Thomson *et al*. 1978).

The decapods *Lebbeus polaris*, *L. groenlandicus*, *Argis dentata* and *Sclerocrangon boreas* were observed by divers or taken in trawls at depths less than 50 m. The isopod *Arcturus baffini* formed dense concentrations at depths of 25 to 50 m off the Phoenix Head Glacier.

In general, the quantitative distribution and ecology of epibenthic invertebrates living deeper than the barren zone in the high arctic have not been studied.

2.5.5 Macrophytic Algae

A prominent feature of most nearshore marine areas is the presence of large plants, commonly called macrophytes or benthic algae. Where these plants are abundant, they fix large amounts of carbon through photosynthesis and contribute substantially to the total primary productivity of nearshore areas. According to Mann and Chapman (1975), from 1000 to 2000 g C/m^2 can be fixed annually by macrophytes along the coast of eastern Canada. Normally, only a small portion of macrophyte production is consumed directly by herbivores. Most of the plants' productivity enters the food chain as detritus and dissolved organic matter (Miller and Mann 1973). These products form the base of an elaborate food web involving lower trophic levels and, indirectly, vertebrates. Benthic algae also provide habitats for a large number of invertebrates and fish, leading to a greater diversity and abundance of animals in a particular area (e.g. Mohr *et al*. 1957).

Table 2.5.6. Mean abundance (no./m^2 ± SD) of Onisimus litoralis in four depth intervals at five high arctic areas. Number of samples is in parentheses.

Area	Depth range (m)			
	Intertidal	1-2	3-5	6-12
Phoenix Head Glacier[a] (S Devon Island)	6 ± 8 (22)	700 ± 503 (5)	1021 ± 1106 (4)	48 ± 27 (6)
Navy Board Inlet[a] (NW Baffin Island)	3 ± 3 (11)	1 to 50 (4)	71 ± 38 (3)	Not sampled
Outer Creswell Bay[b] (E Somerset Island)	240 (40)	147 ± 138 (4)	16 ± 29 (8)	19 ± 38 (4)
Brentford Bay[c] (NE Boothia Peninsula)	58 (15)	109 ± 157 (4)	9 ± 15 (4)	0 (8)
Bridport Inlet[d] (S Melville Island)	0 (21)	Not sampled	6 ± 10 (12)	2 ± 6 (37)

[a] From Thomson and Cross (1980).

[b] From Sekerak et al. (1976a) and Alliston et al. (1976).

[c] From Thomson et al. (1978).

[d] From Buchanan et al. (1977).

Macrophytic algae are restricted to nearshore areas where sufficient light reaches the bottom. They are further concentrated in areas with exposed rocks. Such rocky areas are common in the nearshore zone of the present study area, unlike the situation in the western arctic (Beaufort Sea) where the bottom is usually soft and unsuitable for macrophytes.

The zonation of high arctic macrophytic algae is similar to that found on the Canadian east coast but in the Arctic the upper limit of each zone is found at a deeper depth. Thus, the normally intertidal *Fucus* is most abundant in the barren zone and the *Laminariales* do not appear until a depth of three to five m is reached.

The high arctic intertidal is usually devoid of conspicuous foliose algae. *Fucus* spp. are found in a very few protected locations (Thomson *et al*. 1978; LGL Ltd., unpubl. data).

The *Laminariales* (kelp) are the dominant sublittoral plants in terms of biomass in arctic Canada (Wilce 1973). In the study area kelp (*Laminaria*, especially *L. saccharina*) formed a dense cover on all the hard substrates investigated (Thomson and Cross 1980). The biomasses of *Laminaria* in quantitative samples taken by Thomson and Cross (1980) ranged from 1.7 to 12.7 kg/m^2 and were somewhat lower than those recorded from the east coast of Canada by Mann (1972) and MacFarlane (1952, in Mann 1973).

Agarum cribrosum (a kelp) usually replaces *Laminaria* as the dominant form at depths of 10 m (Wilce 1973; Thomson and Cross 1980).

The understory community of perennial and annual species occurring under the kelp canopy, as described by Wilce (1973), was found at most locations in the study area. The biomass of the understory was generally lower than that of the kelp canopy (Table 2.5.7). The brown alga *Desmarestia aculeata* and the reds *Neodilsea integra*, *Halosaccion rumentaceum* and *Phyllophora truncata* were the most conspicuous of the understory plants.

2.6 Marine and Anadromous Fish

No large scale research on fishes in the marine system has been conducted in the study area. Thus knowledge of abundance, distribution and even species composition is fragmentary and incomplete. We summarized the information available up to 1976 for the Lancaster Sound region in Norlands Petroleums Ltd. (1978) and much of the following material originates from that document. Since 1976, the list of fish species known to occur in the study area has been supplemented by Sekerak *et al*. (1979), Thomson and Cross (1980) and Sekerak (1982), and a notable contribution on the behaviour and distribution of arctic cod under ice was made by Bradstreet (1980b, 1982a).

In comparison to the waters of west Greenland, where over 86 fish species are known to occur (Hildebrand 1948), Lancaster Sound, northwest Baffin Bay and adjacent regions have few species of fish. At present, only 27 species are known or suspected to occur in the region (Table 2.6.1). Because of the lack of exploratory fisheries research, additional species may be present. With the exception of the cods, arctic char and Greenland shark, the fish species in the study area are primarily bottom-dwellers. Little detailed biological information concerning most species is available.

Table 2.5.7. Biomass (g/m^2) of canopy and understory macrophytic algae in quantitative collections from Philpots Island, Phoenix Head Glacier, Navy Board Inlet, and Eclipse Sound during August-September 1978, and from Cape Fanshawe during August 1979. Data in each column based on one sample (0.25 to 2.5 m^2), except for Cape Fanshawe where n = 5 (5 m) or 6 (10 m).

Depth (m)	Taxon	Philpots Island	Phoenix Head Glacier		Navy Board Inlet		Eclipse Sound		Cape Fanshawe
		31,32[a]	31	34	31	42	31,32[b]	33	31
5	*Laminaria* spp.	3520; 5200					332	3464	541 ± 278
	Alaria grandifolia	240; 4					0	0	53 ± 16
	Agarum cribrosum	0					0	0	2 ± 4
	Total Laminariales	3760; 5204	-	-	-	-	332	3464	596 ± 283
	Desmarestia aculeata	30; 40					1144	20	0
	Halosaccion ramentaceum	0					0	0	70 ± 49
	Neodilsea integra	0					0	100	35 ± 23
	Phyllophora truncata	0					0	36	0
	Other	27; 11					48	0	18 ± 12
	Total understory	57; 51	-	-	-		1192	156	122 ± 67
	Total macrophytes	3817; 5255	-	-	-	-	1524	3620	718 ± 238
10	*Laminaria* spp.	1700	1706	2830; 4400	4372	12652	0	0	0
	Alaria grandifolia	0	20	0; 28	658	104	0	0	<1
	Agarum cribrosum	0	0	2; 0	0	0	1033	0	416 ± 187
	Total Laminariales	1700	1726	2832; 4428	5030	12828[c]	1033	0	416 ± 187
	Desmarestia aculeata	545	4	0	0	0	0	420	0
	Halosaccion ramentaceum	0	0	0	64	348	0	0	0
	Neodilsea integra	0	0	0	0	0	0	1080	0
	Phyllophora truncata	0	0	0	0	0	0	208	0
	Other	0	0	0	20	24	0	0	0
	Total understory	545	4	0	84	372	0	1708	<1
	Total macrophytes	2245	1730	2832; 4428	5114	13200	1033	1708	417 ± 187

-Not sampled.

[a] Station 31 = 10 m; 32 = 5 m.

[b] Station 31 = 5 m; 32 = 10 m.

[c] This total also includes *Saccorhiza dermatodea*.

Table 2.6.1. Common and scientific names[1] of fish species known or suspected to occur in Lancaster Sound, west Baffin Bay and immediately adjacent waters.

Name		
Scientific	Common	Reference
Squalidae		
Somniosus microcephalus	Greenland shark	Beck and Mansfield (1969); Mary-Rousselière (1959)
Rajidae		
Raja hyperborea	darkbelly skate	Jensen (1948) LGL Ltd. (unpubl. data)
Salmonidae		
Salvelinus alpinus	arctic char	Ellis (1962)
Gadidae		
Arctogadus glacialis	polar cod	Nielsen and Jensen (1967); Thomson and Cross (1980);
Boreogadus saida	arctic cod	Bohn and McElroy (1976); Sekerak *et al.* (1976b, 1979); Bradstreet (1980b, 1982a);
Gadus ogac	Greenland cod	LGL Ltd. (unpubl. data)
Macrouridae		
Coryphaenoides rupestris	rock grenadier	Ellis (1962)
Zoarcidae		
Gymnelis viridis	fish doctor	Ellis (1962); Thomson and Cross (1980)
Lycodes mucosus	saddled eelpout	Thomson and Cross (1980)
Lycodes polaris	polar eelpout	LGL Ltd. (unpubl. data)
Agonidae		
Agonus decagonus	sea poacher	LGL Ltd. (Unpubl. data)
Cottidae		
Artediellus scaber	rough hookear	suspected
Gymnocanthus tricuspis	arctic staghorn	Ellis (1962); Thomson and Cross (1980)
Icelus bicornis	twohorn sculpin	Ellis (1962)
Icelus spatula	spatulate sculpin	Thomson and Cross (1980)
Myoxocephalus quadricornis	fourhorn sculpin	Ellis (1962)
Myoxocephalus scorpioides	arctic sculpin	Ellis (1962); Thomson and Cross (1980)
Myoxocephalus scorpius	shorthorn sculpin	Ellis (1962); Thomson and Cross (1980)
Triglops pingelii	ribbed sculpin	Thomson and Cross (1980)

Table 2.6.1. Cont'd.

Name		
Scientific	Common	Reference
Cyclopteridae		
Cyclopteropsis jordani	smooth lumpfish	Ellis (1962)
Eumicrotremus derjugini	leatherfin lumpsucker	Thomson and Cross (1980)
Eumicrotremus spinosus	Atlantic spiny lumpsucker	Thomson and Cross (1980)
Liparis tunicatus	Greenland seasnail	Sekerak *et al*. (1979)
Liparis gibbus[2]	dusky snailfish	Sekerak *et al*. (1979)
Liparis fabricii[2]	gelatinous seasnail	Sekerak *et al*. (1979)
Pleuronectidae		
Reinhardtius hippoglossoides	Greenland halibut	Finley and Gibb (MS)
Gonostomatidae		
Cyclothone microdon	veiled anglemouth	Sekerak *et al*. (1979)
Scorpaenidae		
Sebastes marinus	redfish	Finley and Gibb (MS)

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[1] Scientific and common names are from Legendre *et al*. (1975) and Leim and Scott (1966).

[2] Reported as *L. cyclostigma* and *L. koefoedi* by Sekerak *et al*. (1979). Differences are due to recent changes in scientific nomenclature.

2.6.1. Greenland Shark

Greenland sharks 214-305 cm long have been taken in Eclipse Sound near Pond Inlet (Mary-Rousselière 1959) and in Koluktoo Bay (Beck and Mansfield 1969). Though apparently a deep-water species (caught at a maximum depth of 700 metres in Greenland waters) Greenland sharks are caught by west Greenland Eskimos by jigging with 'light' hooks and lines under the ice during winter (Jensen 1948). During the open-water season, the Greenland shark is often attracted to surface waters by offal from sealing or whaling operations (Beck and Mansfield 1969).

Little is known regarding the reproductive biology of the Greenland shark. It is uncertain whether the female is oviparous (egg-laying) or ovoviviparous (live-bearing). No females containing embryos have been caught (Hildebrand 1948), but the ovary of one female contained about 110 soft, shell-less eggs ranging in diameter from eight to 35 mm (Jensen 1948). Dunbar and Hildebrand (1952:90) state that 'It is not beyond the bounds of possibility that fertilization in this species may be external'.

Growth rate and age at maturity of the Greenland shark are unknown. However, Beck and Mansfield (1969) reported that males up to 311 cm long and females up to 295 cm caught at Koluktoo Bay, Baffin Island (72°06'N; 80°47'W), were sexually immature. The largest Greenland shark known is reported as being 731 cm long (Dunbar 1970).

The food of the Greenland shark consists of carrion (Hildebrand 1948), fish and seals (Dunbar and Hildebrand 1952), egg cases of Raja hyperborea (Beck and Mansfield 1969) and large invertebrates (Jensen 1948). This species, although not exploited either on a subsistence or commercial basis in the eastern Canadian arctic, is part of the Danish commercial catch in Greenland waters. In Greenland, the annual production of shark liver, which has a high vitamin A content, was approximately 700 tons in the period 1931-39; in 1952, it was 358 tons (Dunbar 1970). The flesh is also edible, but must be cleansed prior to consumption in order to remove urea, which is utilized by sharks in their normal osmoregulatory processes.

2.6.2 Skates

Of the three skate species reported to occur in the Canadian Arctic (i.e. Raja hyperborea, R. mollis and R. radiata), the darkbelly skate (R. hyperborea) is the species most likely to occur in the study area, since this species prefers cold water. Jensen (1948) described the darkbelly skate as a deep-water species inhabiting depths to 2400 metres. In the eastern Canadian arctic, R. hyperborea has been taken in Jones Sound, Smith Sound and the southern part of Baffin Bay (Jensen 1948). Two specimens of R. hyperborea were taken by longline at a depth of 600 m in Pond Inlet in December 1978 (LGL Ltd., unpubl. data).

No information is available concerning the spawning period of R. hyperborea or the fecundity of mature females. Individual eggs are contained in egg capsules (81 to 125 mm long), which are deposited on the bottom in deep water (490-1200 m) (Jensen 1948). The largest male reported by Jensen (1948) measured 87 cm in length; the largest female was 72 cm. Hildebrand (1948) stated that small fish and invertebrates are the diet of the darkbelly skate and also that this species has no economic value in arctic Canada.

Table 2.6.2. General biological characteristics of the sculpin species known or thought to occur in Lancaster Sound and western Baffin Bay. From Norlands Petroleums Ltd. (1978).

Species	Typical Adult Size (mm total length)	Spawning Time	Egg Size (mm)	Fecundity Range	General Habitat Preferences and Description
rough hookear sculpin (*Artediellus scaber*)	<100	fall	2.7	<100 eggs	benthic—living in shallow coastal waters <50 m deep.
arctic staghorn sculpin (*Gymnocanthus tricuspis*)	-	after September	2.0	2060-3512 eggs	benthic—generally found in coastal waters <100 m deep; tolerates relatively wide range of temperatures (-1.6 to +12.5°C) and salinities (16 to 30°/oo).
twohorn sculpin (*Icelus bicornis*)	80-90	August-October	3.1	147-680 eggs	benthic—occupying mud bottoms, sometimes with admixture of sand and stones. Depth preference increases with age—found up to 560 m deep. In arctic prefers water below 0°C and salinities of 33 to 35°/oo. Can tolerate lower salinities.
spatulate sculpin (*Icelus spatula*)	77-92	August-September	1.4	1100-1300 eggs	common on stony or mud-sand bottoms. Occupies shallow, coastal zone (13-130 m). Tolerates wide range of temp. (-1.7 to +7.8°C) and salinities (24.7 to 34°/oo).
fourhorn sculpin (*Myoxocephalus quadricornis*)	250-300	late fall early winter	2.0	2180-6150 eggs	generally found in shallow coastal waters. Tolerates marine, brackish and fresh water. Inhabits rocky and sand-mud substrates. Longevity to 14 years of age.
arctic sculpin (*Myoxocephalus scorpioides*)	180-220	late fall	1.3	-	inhabits coastal zone and is tolerant of brackish water (17°/oo).
shorthorn sculpin (*Myoxocephalus scorpius*)	250-300	December-June	2.0-2.5	up to 2700 eggs	inhabits depths from shallow coastal water to 250 m; tolerates salinities from 24 to 34°/oo.
ribbed sculpin (*Triglops pingelii*)	<100	September-October	3.0	297-400 eggs	regarded as a coastal species occurring to depths of 190 m; euryhaline, tolerating salinities as low as 16°/oo.

2.6.3 Arctic Char

Salvelinus alpinus is circumpolar and is the most northerly distributed of the freshwater fishes. Arctic char may either be anadromous, migrating to sea in the spring and returning to fresh water in the fall, or resident, remaining permanently in fresh water. Resident char are often isolated from the sea by waterfalls or other barriers. The following material relates only to anadromous char. Because of their great subsistence, sport and commercial value, considerable research has been devoted to the biology and systematics of arctic char throughout their range. Detailed information, primarily on eastern arctic char, is in the excellent monograph by Johnson (1980).

In eastern arctic Canada, arctic char spawn in September and October, usually over gravel areas of lakes. In general, spawning in this species is not more frequent than every other year (Yessipov 1935; Grainger 1953; Lee 1969; Sekerak and Graves 1975; Johnson 1980). From 2700 to 7000 eggs are laid (Dunbar 1970) and egg diameters, prior to their release, are generally 4.0 mm. Young-of-the-year emerge from the gravel in May or June (Yoshihara 1974; Bain 1975) and spend the next few years in fresh water. The age at first seaward migration (smolting) varies widely, from two to nine years (Johnson 1980). In the eastern Canadian arctic, anadromous arctic char attain maturity at ages ranging from 10 to 13 years (Sekerak et al. 1976a; Johnson 1980) and they may live as long as 30 years. The average weight of anadromous arctic char varies among populations, but is normally from one to four and a half kg.

When at sea, arctic char feed in shallow, nearshore coastal areas (Sekerak *et al*. 1976a), where the water is sometimes warmer and less saline (Craig and Haldorson 1981). Most apparently remain within 30 or 40 km of their natal rivers, but long distance movements (e.g., 400 km) have been documented and intermingling of some stocks takes place (Johnson 1980). The marine diet of arctic char consists primarily of crustaceans. Amphipods often dominate their diet (Moore and Moore 1974; Sekerak *et al*. 1976a). Arctic char begin their return migration to fresh water by late July or early August but peak migration into their natal streams may not occur until late August or early September (Johnson 1980).

2.6.3.1 Distribution

The distribution of anadromous arctic char is limited by the physical environment and certain biological characteristics or preferences of the fish. Andersen (1977) reported that caged arctic char held in sea water off Norway survived for two winters; growth was good and 28% of the fish reached maturity. That study demonstrated for the first time the ability of arctic char to grow and overwinter in sea water when the temperature was above 0°C throughout the winter. It is still highly questionable whether char 'stranded' in the sea could survive the subzero temperatures throughout the winter in Lancaster Sound and northwest Baffin Bay. Brett and Alderdice (1958) concluded that no special adaptations have been identified that might enable any species of salmonid to withstand long periods of subzero temperatures; however, no specific research on this question has been performed with arctic char.

Whether or not mortality would result if char remained in the sea, it is obvious that they do not normally do so. Their migratory patterns are well established and movements to overwintering areas in fresh water occur in the latter part of the summer and fall. At this time, many intermittent or small streams draining lakes that are potentially suitable for over-wintering are dry or impassable. Many larger streams may contain sufficient water for upstream migrations but deep pools or lakes for overwintering may be absent. Even large rivers in the high arctic freeze to the bottom in winter; hence most overwintering occurs in lakes. For a freshwater system to support anadromous arctic char, the stream between the sea and the overwintering area must have substantial flow in late summer and fall and barriers to upstream movement must be absent. (Unlike some other salmonids such as salmon, arctic char are not noted for their leaping ability.) Hunter (1976) reported that waterfalls as low as one and a half m were effective blocks to the upstream movements of char. The above factors eliminate many freshwater systems in the study area as habitat for anadromous arctic char. In addition, the overwintering area must have suitable regions for spawning, incubation of eggs and rearing of young. Much of the land in the study area is glaciated, and streams and lakes associated with glaciers contain varying amounts of fine sediments. In general, sediments degrade freshwater habitats by filling interstices between gravel-cobble substrates, thereby eliminating or reducing spawning grounds, as well as the habitat of invertebrates upon which young char feed. The above could also be a factor affecting the distribution of arctic char but at present data are unavailable to support or refute this hypothesis.

There are relatively few published accounts of arctic char distribution in the region between Cape Dyer, on the east coast of Baffin Island, north to Devon Island and Lancaster Sound. Information on the known marine distribution of arctic char in the region was obtained from (1) the Inuit Land Use and Occupancy Project produced by Milton Freeman Research Ltd. (1976); (2) personal communications with residents of Pond Inlet; (3) a limited amount of data obtained by LGL Ltd. in the summer of 1978 from gill netting; and (4) the arctic atlas produced by Fenco/Slaney (1978). Residents of Clyde River and Broughton Island could probably provide additional information about distribution of anadromous char in the southern part of the study area.

Marine locations where anadromous arctic char are suspected to occur have also been considered. These locations, determined by inspection of 1:250,000 topographic maps, appear to have physical characteristics that conform to the habitat requirements of arctic char. These characteristics include:

1. presence of pools or lakes (minimum width of about 0.5 km) within 50 km of the sea;

2. no mapped major waterfalls, series of rapids or excessively steep gradients in the river channel between the sea and potential overwintering areas;

3. sufficient drainage area so that the stream between the sea and possible overwintering areas was definitely not ephemeral and probably contained sufficient water for upstream movement in the fall; and,

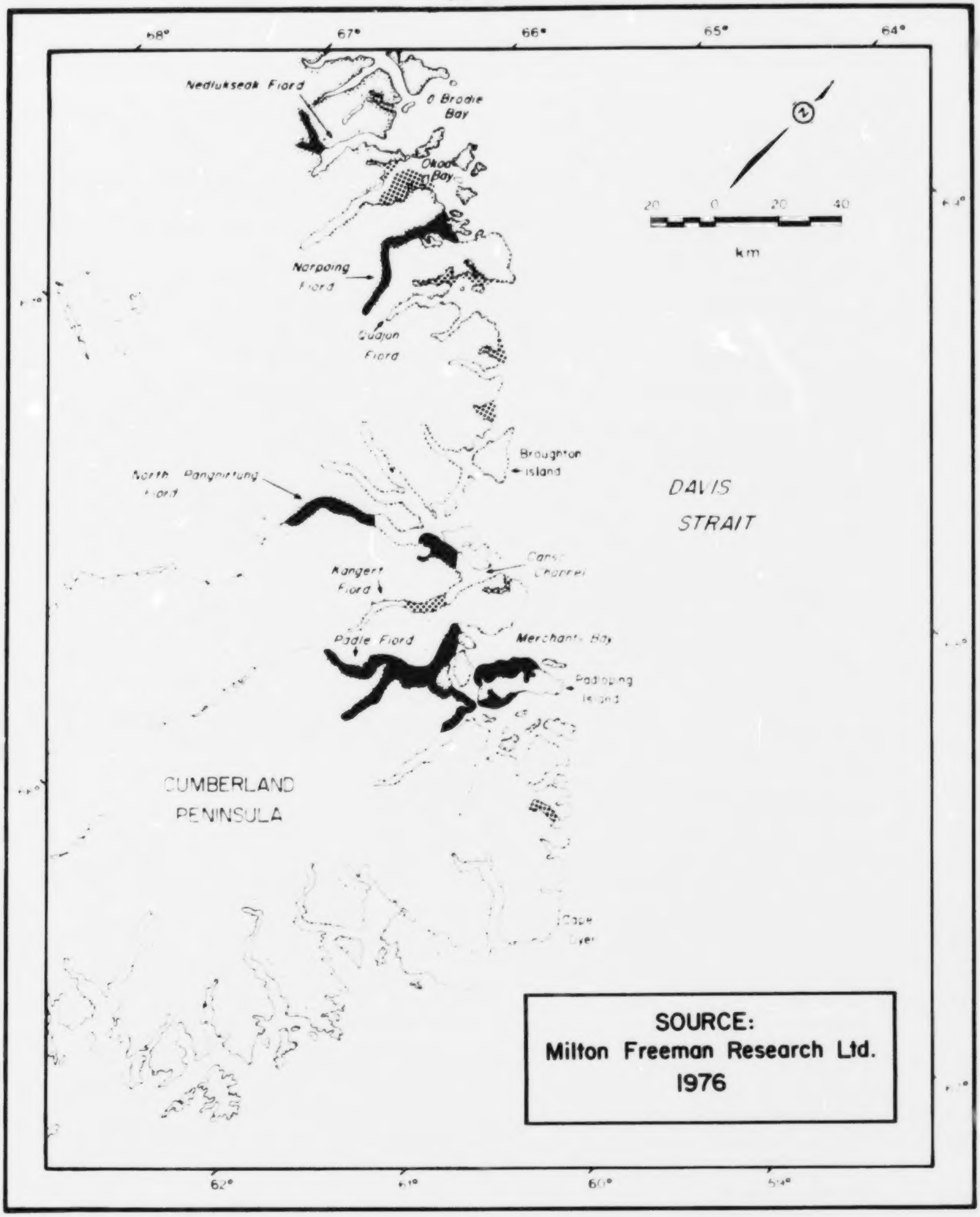

68°
67°
66°
65°
64°
Nedlukseak Fiord
Brodie Bay
Okoa Bay
20
0
20
40
km
Narpaing Fiord
Quajon Fiord
Broughton Island
North Pangnirtung Fiord
DAVIS STRAIT
Kangert Fiord
Canso Channel
Padle Fiord
Merchants Bay
Padloping Island
CUMBERLAND PENINSULA
Cape Dyer
SOURCE:
Milton Freeman Research Ltd.
1976
62°
61°
60°
59°

FIG. 2.6.1. Known (solid black) and suspected (stippled) marine coastal areas of Baffin Island utilized by anadromous arctic char - Cape Dyer to Brodie Bay.

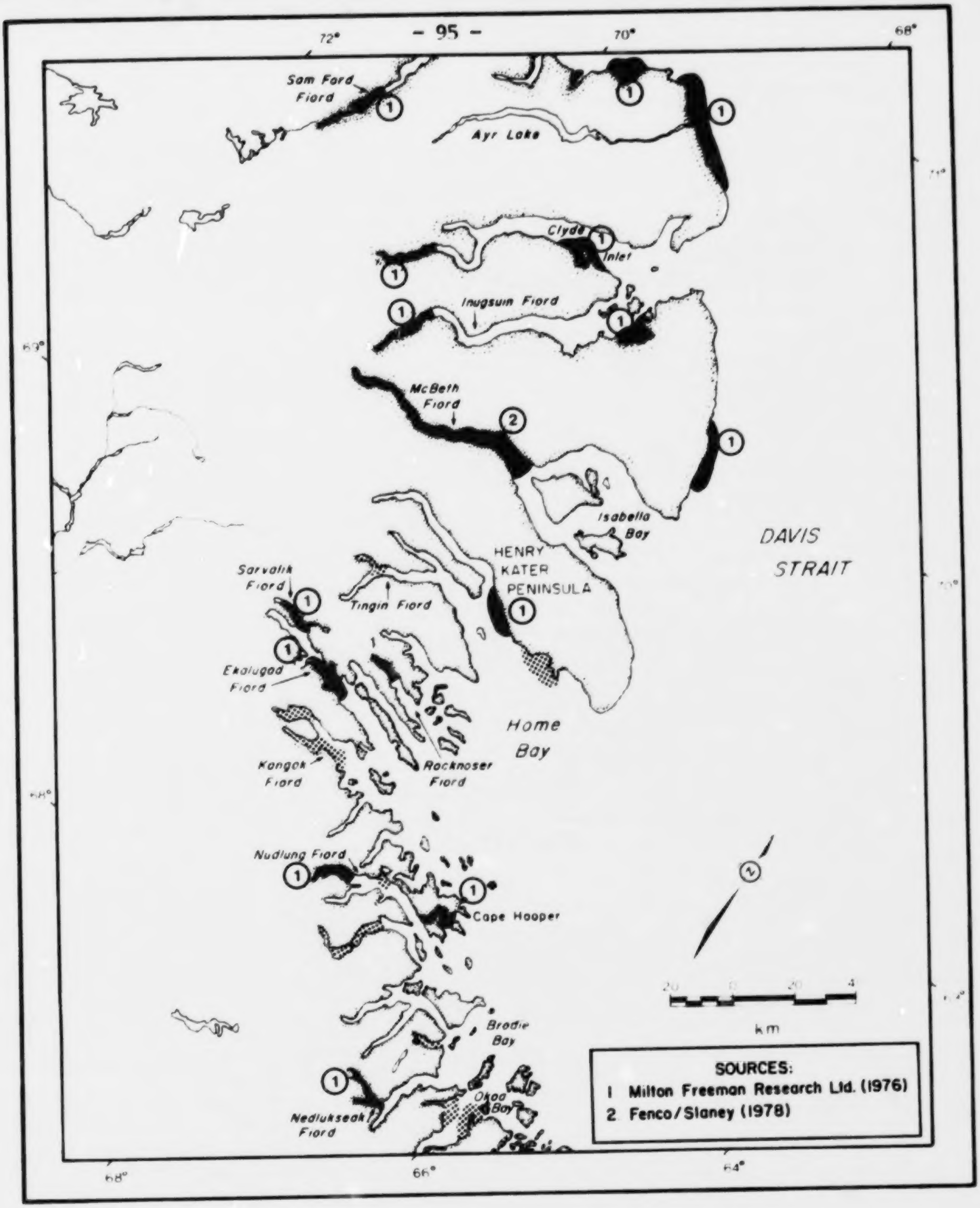

72°
70°
68°
Sam Ford Fiord
Ayr Lake
Clyde Inlet
Inugsuin Fiord
McBeth Fiord
Isabella Bay
DAVIS STRAIT
HENRY KATER PENINSULA
Sarvalik Fiord
Tingin Fiord
Ekalugad Fiord
Home Bay
Kangok Fiord
Rocknoser Fiord
Nudlung Fiord
Cape Hooper
Brodie Bay
Okoa Bay
Nedlukseak Fiord
①
②
20 0 20 40
km
SOURCES:
1 Milton Freeman Research Ltd. (1976)
2 Fenco/Slaney (1978)
68°
66°
64°

FIG. 2.6.2. Known (solid black) and suspected (stippled) marine coastal areas of Baffin Island utilized by anadromous arctic char - Brodie Bay to Sam Ford Fiord.

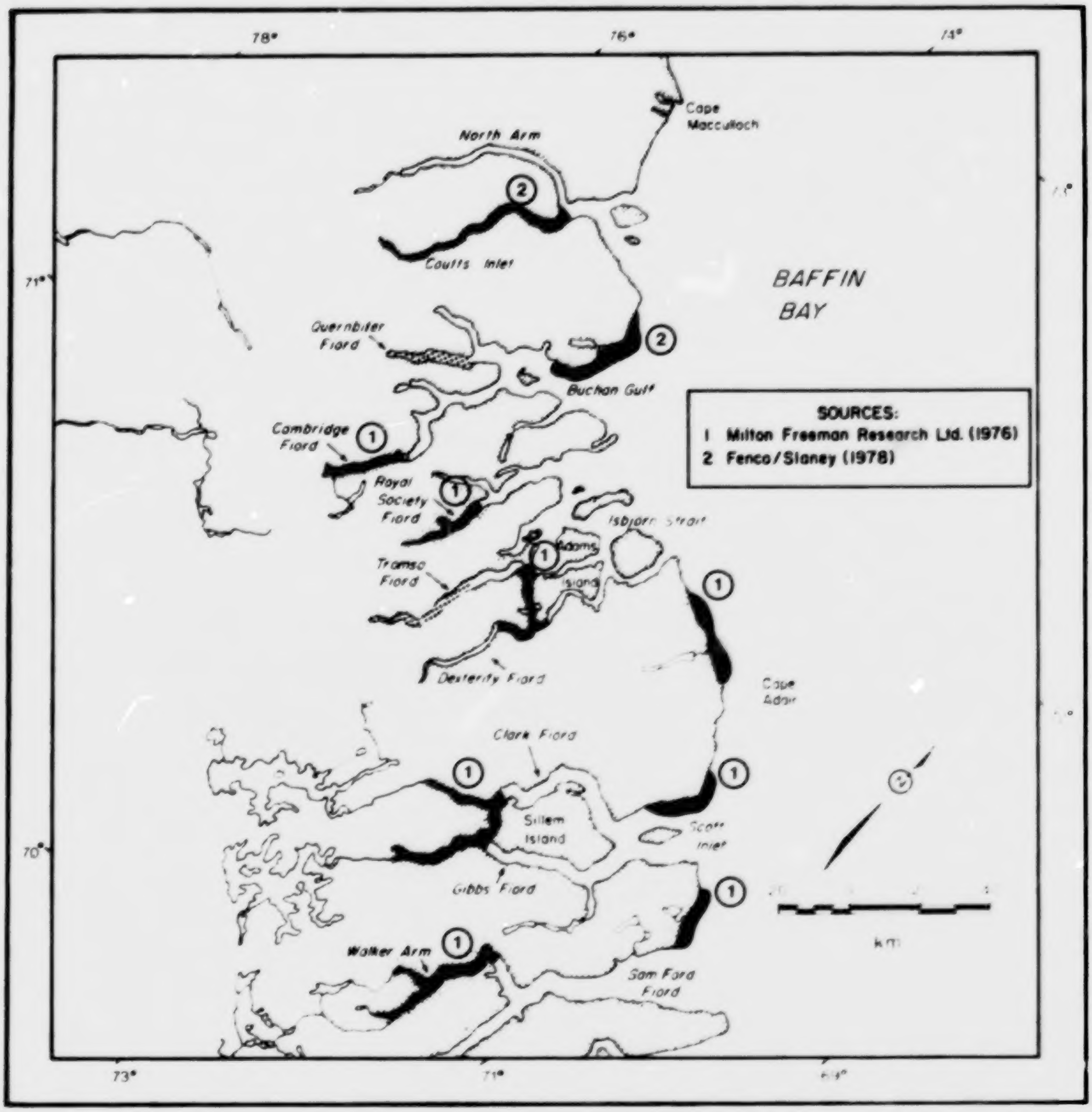

78°
76°
74°
Cape Macculloch
North Arm
②
Coutts Inlet
71°
BAFFIN BAY
Quernbiter Fiord
②
Buchan Gulf
SOURCES:
1 Milton Freeman Research Ltd. (1976)
2 Fenco/Slaney (1978)
Cambridge Fiord
①
Royal Society Fiord
①
Isbjorn Strait
Adams Island
①
Tromso Fiord
①
Dexterity Fiord
Cape Adair
Clark Fiord
①
①
Sillem Island
Scott Inlet
70°
Gibbs Fiord
①
Walker Arm
①
Sam Ford Fiord
km
73°
71°
69°

FIG. 2.6.3. Known (solid black) and suspected (stippled) marine coastal areas of Baffin Island utilized by anadromous arctic char - Sam Ford Fiord to Cape Macculloch.

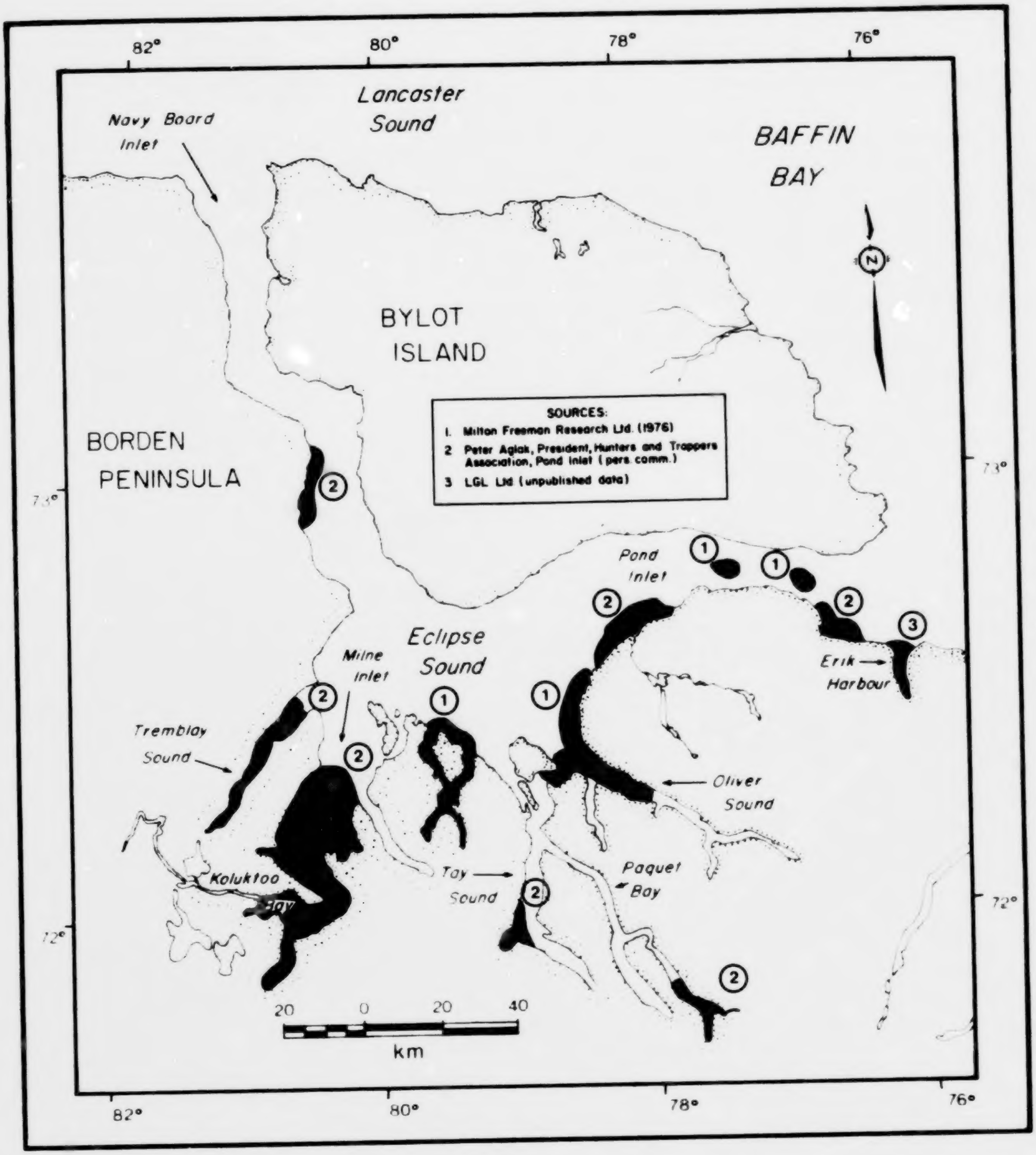

82°
80°
78°
76°
Lancaster Sound
Navy Board Inlet
BAFFIN BAY
BYLOT ISLAND
BORDEN PENINSULA
SOURCES:
1. Milton Freeman Research Ltd. (1976)
2 Peter Aglak, President, Hunters and Trappers Association, Pond Inlet (pers. comm.)
3 LGL Ltd (unpublished data)
73°
Pond Inlet
Eclipse Sound
Milne Inlet
Tremblay Sound
Erik Harbour
Oliver Sound
Koluktoo Bay
Tay Sound
Paquet Bay
72°
①
②
③
20 0 20 40
km

FIG. 2.6.4. Known (solid black) and suspected (stippled) marine coastal areas of Baffin Island utilized by anadromous arctic char - Pond Inlet to Navy Board Inlet.

4. the absence of large glaciers in the immediate vicinity of the drainage, especially near lakes.

Drainages meeting all of the above criteria are potentially suitable habitat for anadromous arctic char. The probable marine distribution of anadromous arctic char originating from such freshwater systems was then mapped in Figures 2.6.1-2.6.4.

In mapping potential distributions of anadromous arctic char, efforts were made to illustrate a conservative range rather than identifying an entire series of fiords as potential range on the basis of scanty information from one. It is emphasized that regions identified by the above process are mapped only as suspected of containing anadromous arctic char. In these terms, areas that may contain important resources are identified.

A map of Lancaster Sound has not been included. Anadromous arctic char have not been documented in this area and inspection of topographical maps indicates that little or no suitable freshwater habitat is present along the borders of the sound.

2.6.4 Gadids (Cods)

Three species of cod are known to occur in the study area. The Greenland cod, *Gadus ogac*, appears to be rare; it has apparently been collected once from northern Prince Regent Inlet (Boulva 1972) and three specimens were taken by hook in Eclipse Sound in August 1979 (LGL Ltd., unpubl. data). It has been confirmed that the specimens obtained from Arctic Bay and reported as Greenland cod in Norlands Petroleums Ltd. (1978) are in fact polar cod, *Arctogadus glacialis*. Polar cod apparently occur sporadically in the study area, having been found in Lancaster Sound (Thomson and Cross 1980), and in marine mammal stomachs from Grise Fiord and Pond Inlet (Finley and Gibb MS).

Arctic Cod

The arctic cod (*Boreogadus saida*) is by far the most abundant and ecologically important fish in the study area. It figures prominently in the diets of many seabirds and marine mammals and is a key link in the transfer of energy to higher vertebrates. These relationships are explained in detail in Section 4.0: Trophic Relationships.

To our knowledge, the only study solely directed toward arctic cod in the North American Arctic was that of Bain and Sekerak (1978). However, several recent contributions concerning the distribution, relative abundance or ecology of arctic cod have been made by Frost *et al*. (1978), Craig and Haldorson (1981) and Craig *et al*. (1982) in the Alaskan Beaufort Sea, and Bradstreet (1980b, 1982a) and Bradstreet and Cross (1980, 1982) in Pond Inlet. Distribution and abundance of planktonic young-of-the-year arctic cod in Lancaster Sound and northwest Baffin Bay have been investigated by Sekerak *et al*. (1976b, 1979). The latter results have been previously summarized (see Section 2.4.3 Ichthyoplankton and Sekerak 1982).

Distribution--The arctic cod is the only species of fish that is common throughout its circumpolar range (Bain and Sekerak 1978). Figure 2.6.5 illustrates its widespread occurrence and its tendency to be more common in

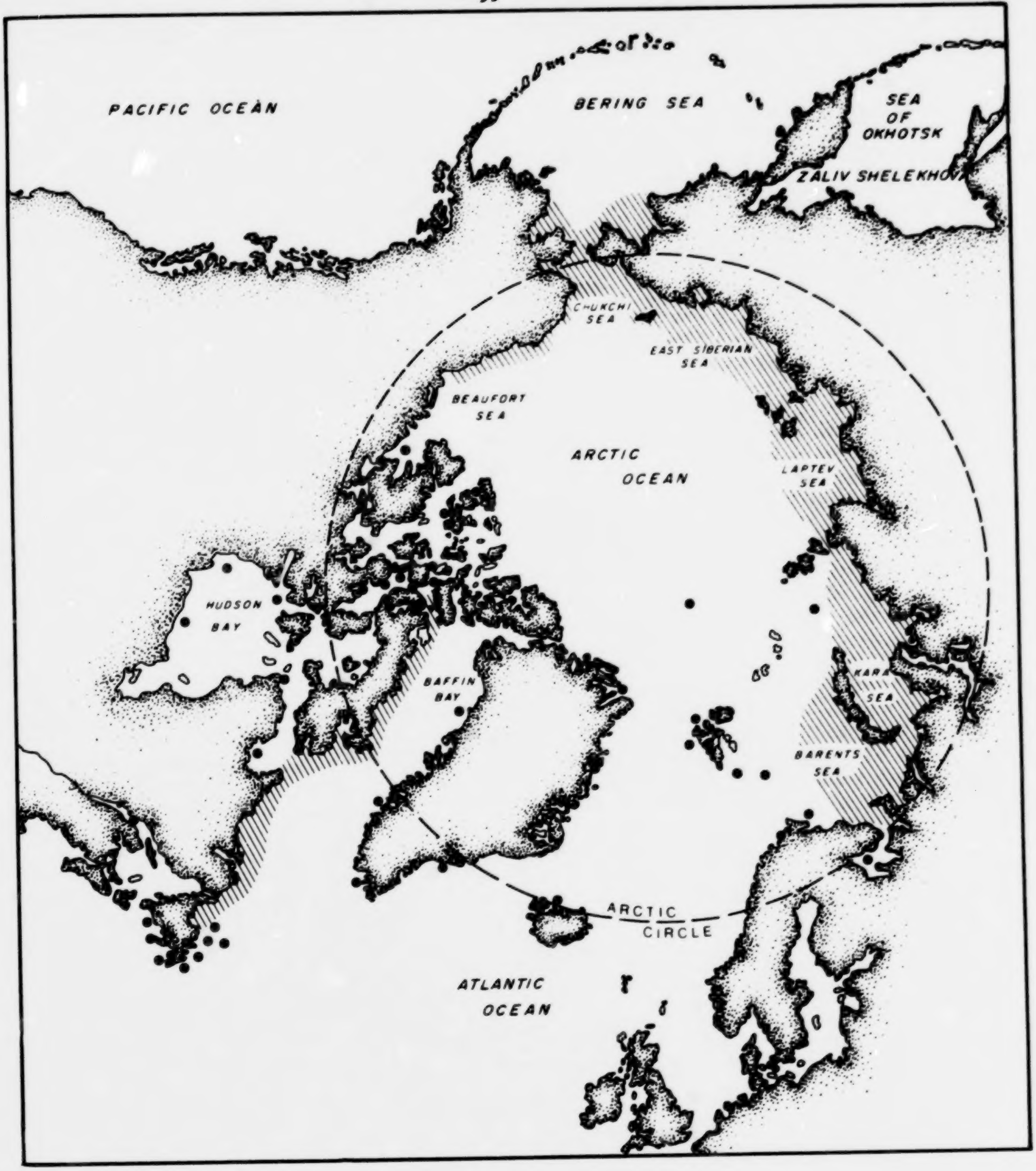

PACIFIC OCEAN
BERING SEA
SEA OF OKHOTSK
ZALIV SHELEKHOVA
CHUKCHI SEA
EAST SIBERIAN SEA
BEAUFORT SEA
ARCTIC OCEAN
LAPTEV SEA
HUDSON BAY
BAFFIN BAY
KARA SEA
BARENTS SEA
ARCTIC CIRCLE
ATLANTIC OCEAN

FIG. 2.6.5. Known distribution of arctic cod (modified from Bain and Sekerak 1978). Hatched areas represent regions where sampling has been sufficiently intense to prove that arctic cod were distributed throughout the region. They do not necessarily represent areas of abundance. The hatched area along Baffin Island primarily represents young-of-the-year cod. Dots represent areas of limited sampling where arctic cod have been captured.

the cold arctic marine waters off eastern North America rather than warm subarctic waters of similar latitudes off western North America and eastern Asia. Jensen (1948) reported that arctic cod preferred cold arctic waters and that they became more common north of the Arctic Circle. Arctic cod have been reported as far north as 88°N latitude (Kleinenberg et al. 1964). It is believed that the absence of arctic cod from specific arctic regions (shown in Figure 2.6.5) generally denotes an absence of research rather than an absence of the species. Only small portions of the Arctic Ocean have been studied, and the distribution of arctic cod (other than young-of-the-year) is poorly understood.

Little information on depth distribution of adult or subadult arctic cod is available. They have been collected at depths of 300 m in Strathcona Sound (Bohn and McElroy 1976), 930 m in Baffin Bay (Jensen 1948) and 400 m in the northern Chukchi Sea and Beaufort Sea (Frost et al. 1978). The planktonic young are concentrated in the upper 20 to 30 m of water and do not appear to be found below 250 m.

Abundance--Few estimates of the abundance or population size(s) of arctic cod are possible at the present time. The relative abundance of arctic cod appears to vary dramatically with both location and season, and comparisons are difficult, because of both the substantial differences in fishing gear among the studies and the brevity of most studies. Frost et al. (1978) reported that arctic cod were most abundant in the northeastern Chukchi Sea (10.3 cod/trawl), moderately abundant between Point Barrow and Prudhoe Bay (7.8/trawl), and least abundant between Prudhoe Bay and Demarcation Point (1.9/trawl). Pereyra et al. (1977) reported 0.9 kg of arctic cod/trawl in the southeastern Chukchi Sea, and only slightly less (0.7 kg/trawl) in the northeastern Bering Sea. Miller (1979) estimated from acoustic survey data that about 89,500 tonnes of arctic cod were present off the northern coast of Newfoundland and southern Labrador in October 1978. Trawl catches indicated that these arctic cod were small -- between 35 and 65 mm in length. Bradstreet (1980a) conservatively estimated that alcids alone removed 1.5×10^6 arctic cod from along the ice edge between Griffith and Beechey islands, in Wellington Channel, during a 35-day period in 1976.

Using admittedly crude approximations, Hunter (1977) estimated that about at least 400,000 tonnes of arctic cod were present in Lancaster Sound (including Prince Regent Inlet south to Creswell Bay, Admiralty Inlet, and Pond Inlet), which amounted to eight g/m^2. Similarly crude approximations in Section 4.0 Trophic Relationships suggest that standing crop of arctic cod (excluding young-of-the-year) is about nine g/m^2 in Lancaster Sound and northwest Baffin Bay. Hunter also indicated, from trawl catches in inshore waters of the Canadian Beaufort Sea, that standing stock of all fish probably varied from 0.04 to one g/m^2.

Variations in the relative abundance of arctic cod are best known in nearshore regions, because such areas are most easily studied. In late summer and autumn, arctic cod appear to move into coastal waters, and at times very large schools are present in restricted areas. Craig and Haldorson (1981) estimated that roughly 23 million arctic cod were present in Simpson Lagoon, Beaufort Sea, between 14 and 22 August 1978. There was also an increase of arctic cod in Simpson Lagoon in the late summer of 1977, but it was of considerably smaller magnitude. Bendock (1979) also noted an increase in the numbers of arctic cod in Prudhoe Bay in late summer and fall of 1976. Increases in the abundance of arctic cod in nearshore waters in the fall have also been recorded in the Russian arctic (Ponomarenko 1968) and the Canadian Arctic in Allen Bay along Cornwallis Island and in Creswell Bay along Somerset Island (Bain and Sekerak 1978). Marine mammals sometimes feed intensively on these nearshore concentrations (e.g., Finley and Gibb MS). Present knowledge is inadequate to predict abundance in specific areas at specific times.

Tens to hundreds of arctic cod also congregate in nearshore cracks in the ice in late June, July and early August. Such schools have been observed in Resolute Bay and Allen Bay, Cornwallis Island, and near Cape Graham Moore, Bylot Island (Bain and Sekerak 1978; Bradstreet 1980b, 1982a).

Life History--The arctic cod is a relatively small fish that is rarely longer than 300 mm or older than five years. Jensen (1948) commented on the unusually large size of three specimens (357-381 mm in length) from eastern Baffin Bay. Adult and subadult cod from the central and eastern Canadian arctic are normally 100-200 mm long. Arctic cod are relatively fast growing and differences in growth among 'populations' are apparent (Fig. 2.6.6). Arctic cod from the northwest Bering Sea are generally larger at a given age than are other populations. Growth of arctic cod in the central high arctic appears to be moderate when compared to other areas.

On the basis of their widespread distribution, arctic cod are assumed to spawn in many areas of the Arctic. At the present time, however, there is very little information on spawning in North American waters. In Soviet waters, they are reported to spawn between the end of December and March, with most activity taking place in January and February (Jensen 1948; Andriashev 1954). Spawning areas appear to be traditional; they have been located in the northwestern Bering Sea, the Barents Sea and the Laptev Sea (Andriashev 1954).

Only two directed efforts have been conducted to identify arctic cod spawning areas in the North American arctic. The only identified spawning area is in nearshore waters of the Alaskan Beaufort Sea, primarily in Steffanson Sound (Craig and Haldorson 1981; Craig et al. 1982). Ripe cod were captured in that area in mid-November 1978, and by mid-February 1979 nearly all cod captured were spawned out. Pre-spawning cod were again captured in nearshore and offshore regions of the Beaufort Sea in November 1979. Efforts to capture spawning arctic cod in the central high arctic near Cornwallis Island were unsuccessful in three attempts during the winter of 1976-77 (Bain and Sekerak 1978). The latter investigators concluded that, although fishing efforts were not intense, large numbers of arctic cod were probably not in the area.

Andriashev (1954) reported that most arctic cod become sexually mature at four years of age; however, this conclusion can be questioned in view of more recent studies. Hognestad (1968) reported maturity at age two in the Barents Sea. Craig and Haldorson (1981) found that, in nearshore areas of the Beaufort Sea, most mature males were ages two and three and mature females were age three. Both Craig and Haldorson (1981) and Bain and Sekerak (1978) found females to outnumber males for ages greater than two years. Because the sex ratio was approximately equal for two-year-olds, the latter authors postulated a higher mortality rate for males.

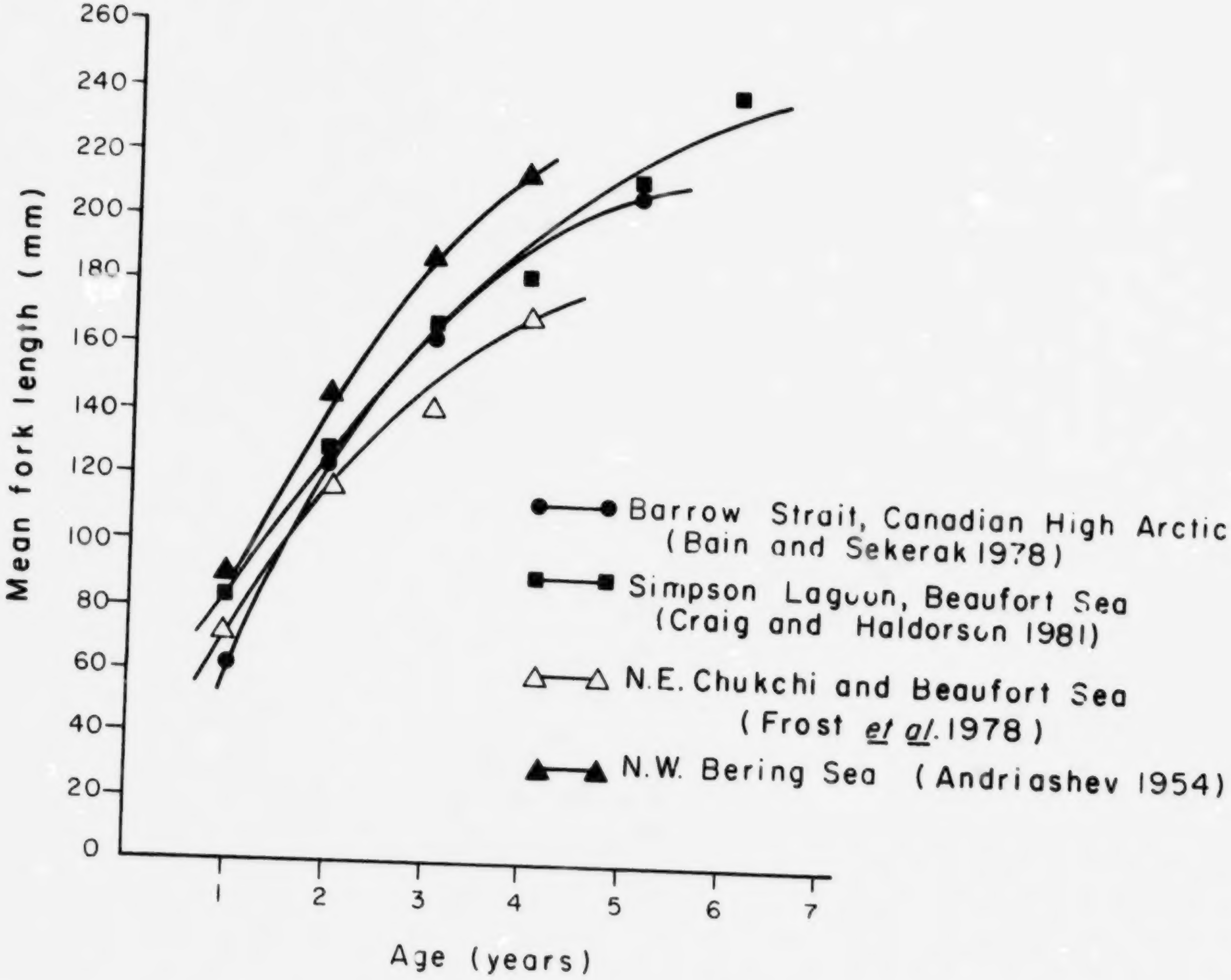


FIG. 2.6.6. Comparison of generalized age-length relationships of arctic cod from various arctic regions. Modified from Bain and Sekerak (1978).

Further information on arctic cod is given in Sections 2.4.3: Ichthyoplankton and 4.0: Trophic Relationships.

2.6.5 Macrourids (Grenadiers)

The macrourids are a highly modified group of fish. In general shape, they have large heads and the body then tapers uniformly to a point--hence the common name 'rat-tail'. Their habitat ranges from abyssal depths to the slopes of continental shelves.

There is only a single record of a macrourid species, the rock grenadier *Coryphaenoides rupestris*, in the study area. Ellis (1962) reported a single specimen in a seal hole in Eclipse Sound, Baffin Island. Jensen (1948) described the rock grenadier as a deep-water species found at depths exceeding 1300 m in west Greenland waters. Specimens reported by Jensen (1948) range in size from 3.5 to 100 cm.

2.6.6 Zoarcids (Eelpouts)

Members of the family Zoarcidae are considerably elongated but relatively small (seldom exceeding 30 to 35 cm) demersal fish. Three species are known to occur in Lancaster Sound and northwest Baffin Bay.

Zoarcids are generally fall spawners. Mature eggs are large (three mm for *Gymnelis viridis*, four-five mm for *Lycodes polaris*) and fecundities are low (100 eggs for both species; Andriashev 1954). Larvae are benthic, as are the adults (Andriashev 1954). Eelpouts occupy the relatively shallow, coastal waters of the arctic. *G. viridis* and *L. polaris* have been found to depths of 100 and 190 m, respectively (Andriashev 1954).

2.6.7 Cottids (Sculpins)

Members of the sculpin family are predominantly marine, bottom-dwelling species, inhabiting shallow to moderate depths of continental shelves. Sculpin species occurring in the Arctic generally spawn from late summer to early winter (Andriashev 1954). Eggs are deposited on the bottom and some larvae are pelagic.

Table 2.6.2 lists the general biological and habitat features of eight sculpin species known to occur in the study area. Information presented in Table 2.6.2 is abstracted from Hildebrand (1948), Andriashev (1954), Walters (1955) and Griffiths *et al*. (1975). Quantitative data regarding the abundance and distribution of sculpin species in the Lancaster Sound and Baffin Bay area are lacking. However, two sculpins, *Gymnocanthus tricuspis* and *Myoxocephalus scorpius*, were the most common fish species collected in northwest Baffin Bay and eastern Lancaster Sound in 1978 (Thomson *et al*. 1979).

2.6.8 Cyclopterids (Lumpsuckers and Seasnails)

Three species of lumpsuckers and three species of seasnails are known to occur in the study area (Table 2.6.1). Lumpsuckers and seasnails are especially adapted for a demersal lifestyle; they possess a ventrally-located thoracic disc, which is a modification of the pelvic fins and is a holdfast structure. Generally, cyclopterids occur in shallow to moderately deep water (up to 300 m and rarely deeper) of continental shelves (Andriashev 1954). The preferred habitats are rocky substrates and the fronds of attached, macrophytic algae. However, Andriashev (1954) stated that species of this family have been captured on sandy substrates having an admixture of gravel. Spawning, at least for Eumicrotremus derjugini and E. spinosus, occurs in the fall. Eggs are large (four to five mm for E. derjugini) and are deposited on the bottom. According to Andriashev (1954), the newly-hatched larvae of the majority of cylopterid species are either non-planktonic or are planktonic for only a very short period. In contrast, seasnail young-of-the-year are planktonic for much of the open water season, and made up a substantial portion of the ichthyoplankton in Lancaster Sound and northwest Baffin Bay (see Section 2.4.3).

2.6.9 Greenland Halibut

Immature and adult Greenland halibut (Reinhardtius hippoglossoides) are bottom-dwellers found in deep water (250-1600m) along the west coast of Greenland as far north as Smith Sound (Jensen 1935). In Canadian waters, they are common at least as far north as southern Baffin Island (Leim and Scott 1966). Greenland halibut have been taken by longlines in Pond Inlet and they are frequently found in the stomachs of narwhals and hooded seals in the Pond Inlet area (Finley and Gibb MS). Based on its known distribution and temperature range (generally, between -1 and +4°C, Lear 1970), the Greenland halibut could occur throughout the study area.

Spawning occurs in late winter or early spring and normally terminates by June. Mature Greenland halibut undertake long migrations to the offshore spawning grounds of Davis Strait where the Holsteinsborg-Cumberland Ridge (67°N) forms the northern boundary of their known spawning ground (Jensen 1935). During spawning, this species actively seeks the Atlantic water layer where water temperatures range from 3.5 to 4.5°C and salinities are greater than $34.5^{0}/oo$. Because of their temperature and salinity preferences during the spawning period, Greenland halibut may not spawn in the northern extremes of this range.

Mature eggs are 4.0-4.5 mm in diameter and many are laid; in large females the number of eggs is approximately 300,000. Newly hatched larvae (10-18 mm long) are bathypelagic, occurring at depths from 600 to 1000 m. They later rise toward the surface and are found mainly at depths of about 300 m. When Greenland halibut are about 50 mm long, the left eye begins to migrate and by 80+ mm, metamorphosis to an asymmetrical body shape is well under way. Their pelagic life-stage ends near the end of their first growing season when they are about 70 mm long (Jensen 1935).

Adult Greenland halibut attain a length of about 100 cm and a weight of five to ten kg. Lear (1970) reported Greenland halibut as old as 21 years in Newfoundland waters. This species is of considerable commercial value to the Greenland and Danish fisheries and is also an important part of the Newfoundland fishery.

2.6.10 Gonastomatidae (Anglemouths)

Sekerak et al. (1979) reported that one anglemouth was obtained from a 0.5 m plankton net towed vertically from 1200 m in offshore waters of Baffin Bay, north of Clyde River. The specimen was 71 mm long (total length) and weighed 2.34 g and was tentatively identified as Cyolothone microdon. Leim and Scott (1966) have recorded only four specimens of C. microdon in the Canadian north Atlantic. Hart (1973) reported that this species also occurs in the north Pacific from California to the Bering Sea.

Anglemouths are bathypelagic, deep-sea fishes that are widely distributed throughout the world's oceans. Due to their habitat, which is seldom fished, relatively few specimens have been studied and consequently their taxonomy and biology are poorly known.

2.6.11 Redfish

The redfish (Sebastes marinus) is abundant in north Atlantic waters, where it is a commercially important species. Leim and Scott (1966) reported that redfish are occasionally taken off the coast of southern Baffin Island. An entire specimen of S. marinus and several otoliths of this species have been retrieved from narwhal stomachs taken at the mouth of Pond Inlet (Finley and Gibb MS).

2.7 Marine Birds

This section reviews the distributions and movements of marine birds in the eastern Lancaster Sound-western Baffin Bay area. The following accounts are based primarily on the results of aerial surveys conducted in eastern Lancaster Sound and western Baffin Bay in 1978 and 1979. In general, surveys were flown along predetermined transects at one- to two-week intervals. Surveys were conducted from 4 May to 10 October 1978, and from 9 May to 15 July 1979. Each survey included flights along most edges of landfast ice and ice-free coastlines in the region, and over sample areas of pack ice and open water seaward of the coasts and ice edges. Details of the methodology and the areas surveyed are presented in McLaren and Renaud (1979) and McLaren (1980). The results of these surveys have been supplemented by those of surveys conducted along a standard route in eastern Lancaster Sound in May-September 1976 (Johnson et al. 1976a); the 1976 work was also reviewed in Norlands Petroleums Ltd. (1978). Survey routes flown during each of the three years are shown in Figure 2.7.1. In the following accounts, references are frequently made to one or more of the original reports. Many of the data have been published in McLaren (1982), McLaren and McLaren (1982), McLaren and Renaud (1982), Renaud and McLaren (1982) and Renaud et al. (1982).

Twenty-five species of birds were recorded in the eastern Lancaster Sound-western Baffin Bay area during surveys in 1978 and 1979. The distributions, abundances and habitat use of the more common species are discussed in detail in the following accounts. The less abundant species are summarized briefly in a final 'Other Species' section.

The data describing bird distribution in the area were collected during aerial surveys. Such surveys have several limitations and biases; these have been discussed in detail in McLaren (1982). Even under ideal conditions, observers do not see all birds that are present in the surveyed area. Consequently, aerial surveys provide only indices of population sizes rather than unbiased estimates of total numbers. These indices, which are called 'densities' below, but which are more properly termed 'apparent densities', are useful in identifying temporal and spatial trends in a species' abundance and distribution but they cannot be used for detailed comparisons of the numbers of different species.

Estimates of numbers, rather than densities, have been employed frequently in the following accounts to describe the distribution of birds in offshore waters. For purposes of this section 'offshore' is considered to be the area more than seven km seaward of a coast or fast ice edge. The techniques employed to obtain these estimates have been described in McLaren (1980). These estimated numbers are based on the apparent densities recorded during aerial surveys, and are thus likely conservative.

2.7.1 Northern Fulmar

The northern fulmar (Fulmarus glacialis) is a common seabird in the eastern Lancaster Sound-western Baffin Bay area. There are three nesting colonies within this area, with an estimated 52,000-54,000 pairs (Fig. 2.7.2). There are also several colonies directly to the west of the area, along the coasts of Prince Leopold Island, Devon Island, and Baffin Island; these colonies contain an estimated 152,000 nesting pairs (Brown et al. 1975; Nettleship and Gaston 1978; McLaren 1980). Birds from these colonies migrate through the eastern Lancaster Sound-western Baffin Bay area. There are also several colonies along the west coast of Greenland. The fulmars that nest in the high arctic, winter in offshore waters of Davis Strait, the Labrador Sea and the north Atlantic Ocean (Fisher 1952; LGL Ltd., unpubl. data).

Fulmars return to the eastern Lancaster Sound-western Baffin Bay area in late April; individuals have been seen in Lancaster Sound as early as 23 April (Horring 1937). They are common throughout the area by early May. An estimated 18,000 were present on 4-7 May 1978 (McLaren and Renaud 1979), and a few were present at the Prince Leopold Island colony on 2 May 1976 (D.N. Nettleship, pers. comm.). Numbers increase during the first half of May; over half the breeders at Prince Leopold Island were present there on 10-12 May in 1976 (D.N. Nettleship, pers. comm.), and Johnson et al. (1976a) estimated that about 10,000 were present in eastern Lancaster Sound on 9-11 May 1976. Fulmars are also widespread in Baffin Bay in mid-May. McLaren (1980) estimated about 18,000 to be in offshore northern Baffin Bay on 12-15 May 1979. Large flocks may occur along coasts and fast ice edges at this time (McLaren and Renaud 1979; McLaren 1980).

About 20 May, most fulmars undertake a pre-laying exodus, withdrawing completely from the area. There is an apparent initial movement from coasts and ice edges into offshore waters and then a subsequent virtual complete departure from offshore areas of eastern Lancaster Sound and western Baffin Bay. In each of 1976, 1978 and 1979, estimated numbers of birds in Lancaster Sound dropped to a few hundred on 23-26 May (Johnson et al. 1976a; McLaren and Renaud 1979; McLaren 1980). In western Baffin Bay in 1979, numbers dropped from about 50,000 on 17-21 May to about 8500 on 24-26 May (McLaren 1980). Virtually all of the birds seen during the latter survey were in the southern parts of the surveyed area, which suggests that fulmars disperse at

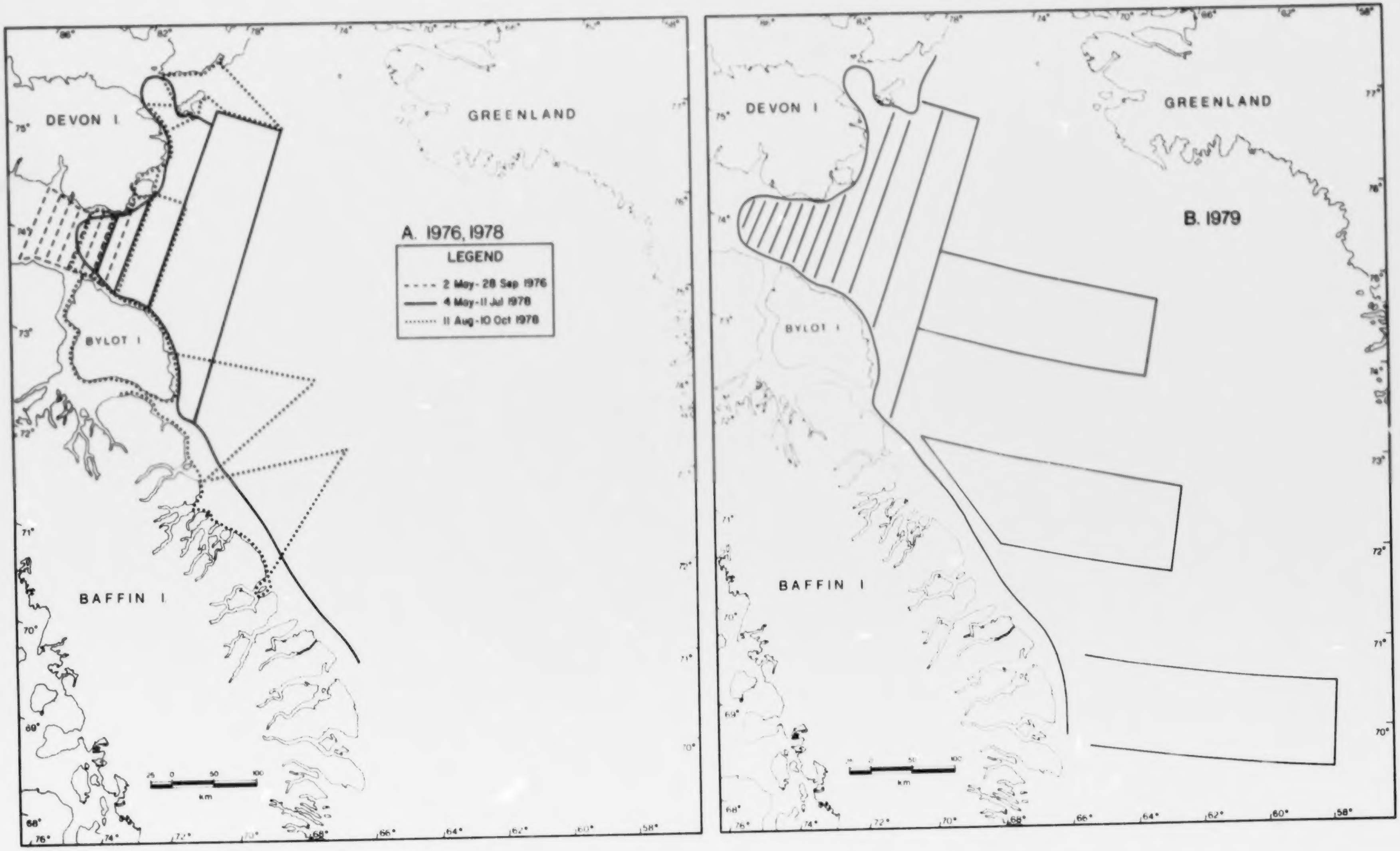

DEVON I
GREENLAND
BYLOT I
BAFFIN I
A. 1976, 1978
LEGEND
2 May-28 Sep 1976
4 May-11 Jul 1978
11 Aug-10 Oct 1978
B. 1979
km
25
0
50
100
75°
74°
73°
72°
71°
70°
69°
68°
77°
76°
86°
82°
78°
74°
70°
66°
64°
62°
60°
58°
76°
72°
68°

FIG. 2.7.1 The eastern Lancaster Sound-west Baffin Bay study area showing survey routes flown in (A) 1976, 1978, and (B) 1979.

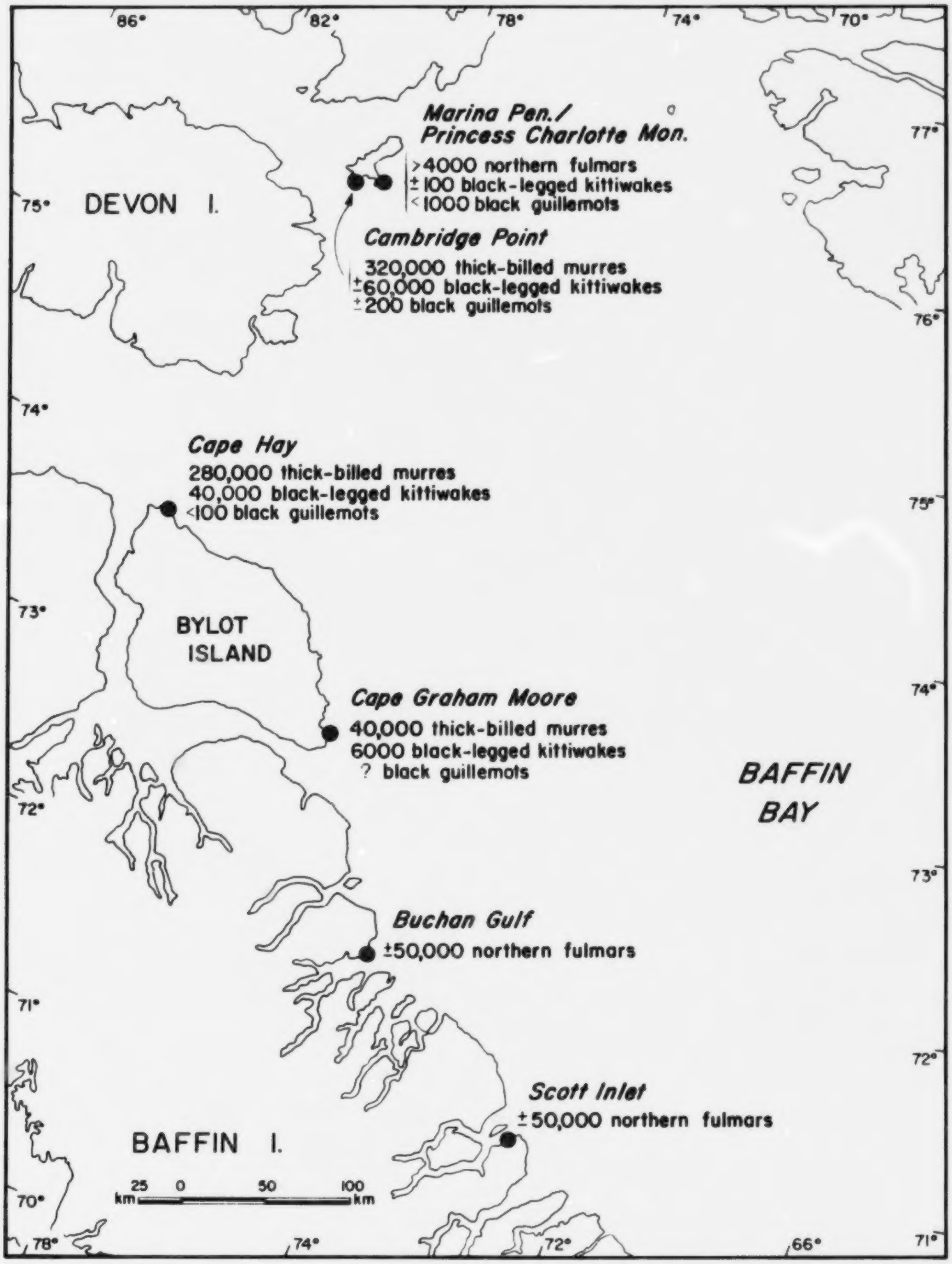

86°
82°
78°
74°
70°
77°
75°
DEVON I.
Marina Pen./
Princess Charlotte Mon.
>4000 northern fulmars
± 100 black-legged kittiwakes
< 1000 black guillemots
Cambridge Point
320,000 thick-billed murres
±60,000 black-legged kittiwakes
±200 black guillemots
76°
74°
Cape Hay
280,000 thick-billed murres
40,000 black-legged kittiwakes
<100 black guillemots
75°
73°
BYLOT
ISLAND
74°
Cape Graham Moore
40,000 thick-billed murres
6000 black-legged kittiwakes
? black guillemots
BAFFIN
BAY
72°
73°
Buchan Gulf
±50,000 northern fulmars
71°
72°
Scott Inlet
±50,000 northern fulmars
BAFFIN I.
25 0 50 100
km km
70°
78°
74°
72°
66°
71°

FIG. 2.7.2 Nesting colonies of seabirds in eastern Lancaster Sound and western Baffin Bay. From McLaren (1982).

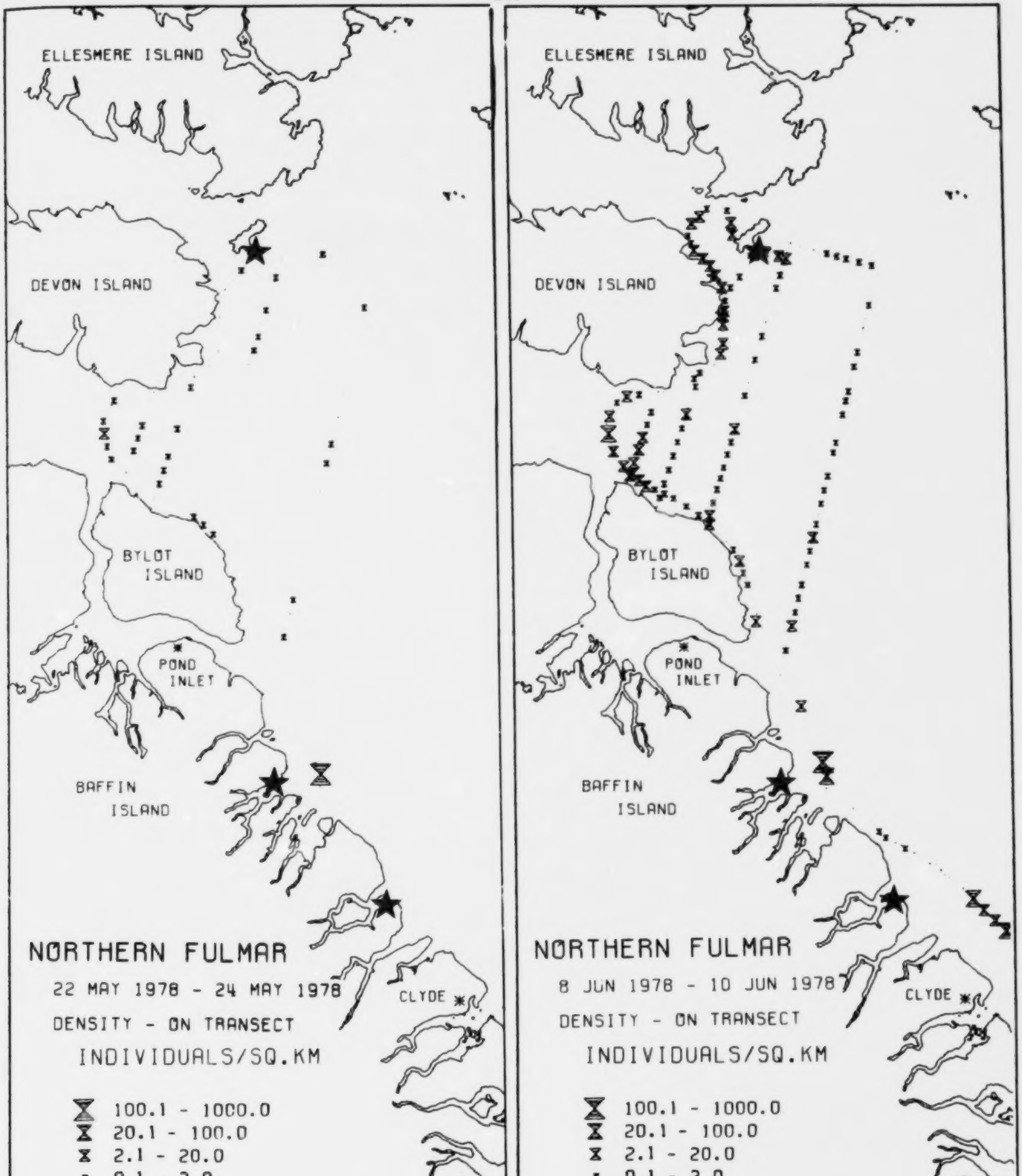

ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
NORTHERN FULMAR
22 MAY 1978 - 24 MAY 1978
DENSITY - ON TRANSECT
INDIVIDUALS/SQ.KM
100.1 - 1000.0
20.1 - 100.0
2.1 - 20.0
0.1 - 2.0
TOTAL COUNTS
ON: 626
ON+OFF: 2191
ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
NORTHERN FULMAR
8 JUN 1978 - 10 JUN 1978
DENSITY - ON TRANSECT
INDIVIDUALS/SQ.KM
100.1 - 1000.0
20.1 - 100.0
2.1 - 20.0
0.1 - 2.0
TOTAL COUNTS
ON: 2940
ON+OFF: 4885

FIG. 2.7.3 Northern fulmar distribution in the study area, 22-24 May and 8-10 June 1978. Densities shown are for four-min (~12 km) transect segments. (★) indicates sites of nesting colonies. From McLaren and Renaud (1979).

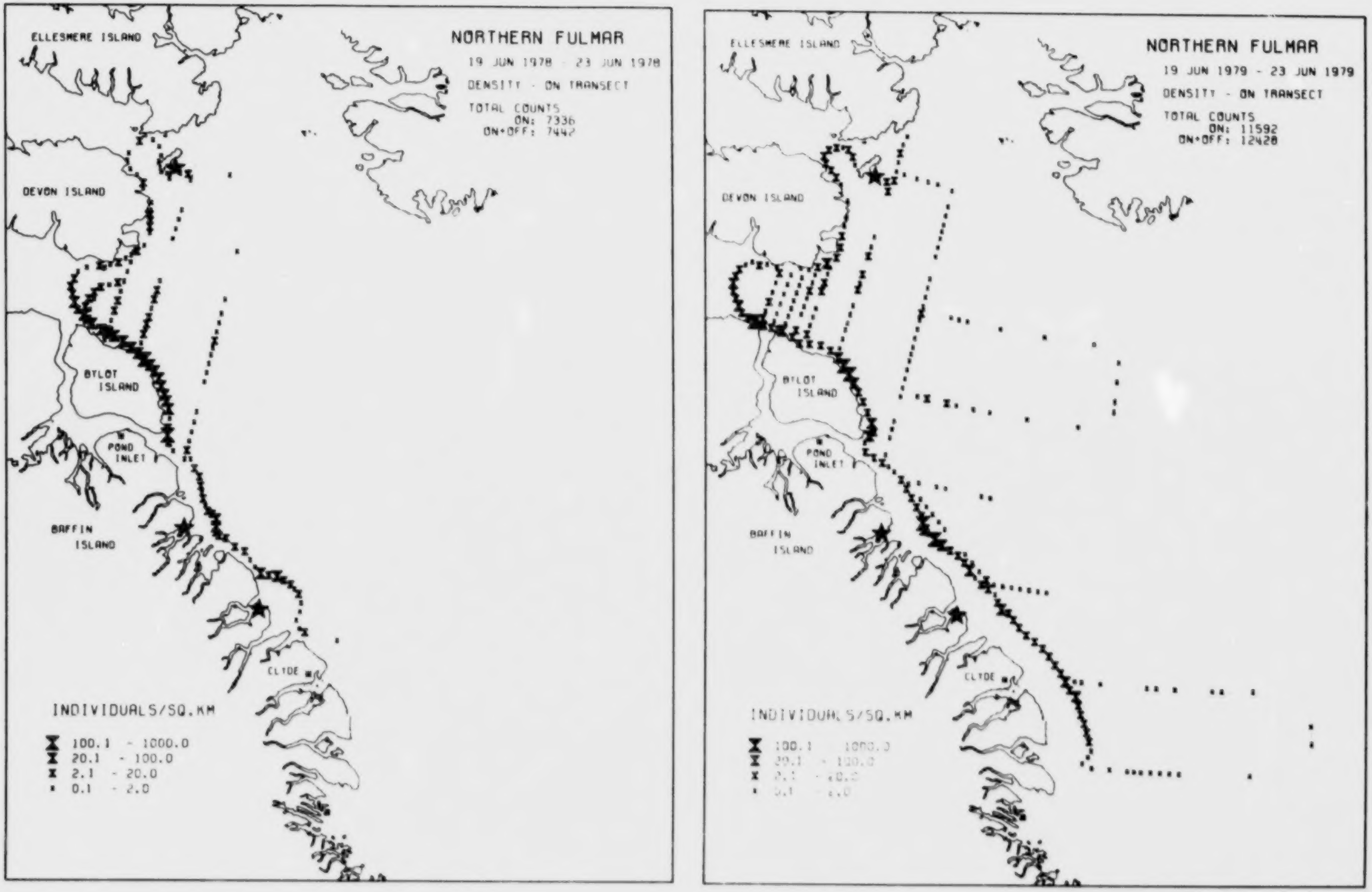

ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
NORTHERN FULMAR
19 JUN 1978 - 23 JUN 1978
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 7336
ON+OFF: 7442
INDIVIDUALS/SQ.KM
100.1 - 1000.0
20.1 - 100.0
2.1 - 20.0
0.1 - 2.0
ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
NORTHERN FULMAR
19 JUN 1979 - 23 JUN 1979
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 11592
ON+OFF: 12428
INDIVIDUALS/SQ.KM
100.1 - 1000.0
20.1 - 100.0
2.1 - 20.0
0.1 - 2.0

FIG. 2.7.4 Northern fulmar distribution in the study area, 19-23 June 1978 and 19-23 June 1979. Densities shown are for 4-min (~12 km) transect segments. (★) indicates sites of nesting colonies. From McLaren and Renaud (1979); McLaren (1980).

this time to the south or southeast, possibly to areas of open water in Davis Strait. In 1976, most fulmars had departed from the Prince Leopold Island colony in the last half of May (D.N. Nettleship, pers. comm.). A pre-laying exodus has been documented at other fulmar colonies (Dunnet et al. 1963; Macdonald 1977) and has been associated with the need to feed intensively at sea in order to acquire energy reserves necessary for egg formation and possibly incubation (Lack 1966; Macdonald 1977).

Fulmars return from their pre-laying exodus during the first week of June. Over 53,000 were estimated to be present in Lancaster Sound and northwest Baffin Bay on 8-10 June 1978, as opposed to an average of 9500 during the period 22 May-2 June 1978 (Fig. 2.7.3; McLaren and Renaud 1979). Similarly, in 1976, estimated numbers in eastern Lancaster Sound increased from 3,800 fulmars on 30 May-1 June to almost 12,000 on 6-7 June, and to 33,000 on 13-15 June (LGL Ltd., unpubl. data). The return is just prior to nest initiation. The peak of egg-laying at Prince Leopold Island was 10 June in 1976 and 11 June in 1978 (D.N. Nettleship, pers. comm.).

The incubation period is about 47 days and eggs hatch in late July (Nettleship et al. 1979). During this six to seven week period, fulmars are widely and generally evenly distributed along most coasts and fast ice edges bordering eastern Lancaster Sound and Baffin Bay. Densities along ice edges and coasts average two to three times higher than those recorded in May, and are about twice as high along fast ice edges as along ice-free coastlines (McLaren and Renaud 1979; McLaren 1980). An important area at this time of year is the landfast ice edge along the northeast side of Bylot Island. Over 4,300 fulmars were seen on a 36-km stretch of the ice edge on 19 June 1979 (McLaren 1980); a similar number was seen on 19 June 1978 (McLaren and Renaud 1979; Fig. 2.7.4). Other areas where large numbers of fulmars concentrate include the fast ice edge east of Coburg Island (over 2,200 fulmars on 28 July 1978), the ice edge across the mouth of Croker Bay, Devon Island (4,800 fulmars on 12 July 1976), the ice edge across the mouth of Navy Board Inlet (4,700 fulmars on 12 July 1976), and the ice edge across the mouth of Pond Inlet (1,400 fulmars on 12 July 1979) (Johnson et al. 1976a; McLaren and Renaud 1979; McLaren 1980). With the exception of the northeast side of Bylot Island, these concentrations do not occur regularly, but seem to be short-term phenomena possibly associated with local ice or other physical conditions.

Numbers of fulmars in offshore waters of eastern Lancaster Sound and northwest Baffin Bay also increase through June and early July. More than 114,000 fulmars (three birds/km^2) were estimated to be present in these waters at the end of June 1979 (McLaren 1980), and over 49,000 (six birds/km^2) were estimated to be present in eastern Lancaster Sound on 4-5 July 1976 (LGL Ltd. unpubl. data). Densities elsewhere in Baffin Bay are <one bird/km^2 during this period. The reason for this increase is unclear. It is possible that many of the birds, at least in 1978, were failed breeders or subadults from the nesting colonies in Lancaster Sound. About 80 percent of the fulmar population at Prince Leopold Island did not nest in that year (D.N. Nettleship, pers. comm.), and these birds would have been forced to move into eastern Lancaster Sound and Baffin Bay because of the presence of fast ice throughout most of Lancaster Sound and Barrow Strait. For the same reason, those that did nest would have been obliged to forage in eastern Lancaster Sound or Baffin Bay. The distance to these waters from the Prince Leopold Island colony is about

300 km, which is believed to be within the foraging range of nesting fulmars (Fisher 1952; Hatch 1979). Nesting success at the colonies in 1979 is not known; however, fast ice again covered much of Barrow Strait and Lancaster Sound until mid-July. It is likely that central arctic nesting birds, either failed or successful, had to forage in easternmost Lancaster Sound and Baffin Bay in that year as well.

It is also possible that the increase in fulmar numbers in offshore waters during June and early July consisted of, at least in part, an incursion of non-breeders into the region. Subadult fulmars were present along the fast ice edge across Pond Inlet in June 1978 (Bradstreet 1980b).

To assess the effects of the presence of fast ice in Lancaster Sound on the distribution of fulmars, one can compare results from 1976 (no fast ice) and from 1978-79 (fast ice present until midsummer). Densities in eastern Lancaster Sound in the first half of May were similar in 1978 and 1979 (1.0 and 1.2 birds/km^2, respectively, McLaren 1980) and were about twice as high as recorded in 1976. As well, hundreds were present along the fast ice edge across Lancaster Sound in 1978 and 1979. The higher densities in 1978 and 1979 were probably caused by the complete absence of open water west of the fast ice edge in those years. Similarly, from early June to mid-July in 1978 and 1979, fulmars were commonly seen both offshore and along the fast ice edge in Lancaster Sound. There were somewhat higher densities in the sound in 1979 than in 1978; this may have been due to the more extensive area of ice-free water offshore in 1979, as fulmars tend to avoid offshore areas with extensive pack ice. However, densities offshore were much higher in 1976 than in 1978 or 1979; this may have been because birds tended to concentrate in large numbers along the fast ice edge across the sound when it was present in 1978 and 1979, or because many birds had moved into western Baffin Bay.

In late July, fulmar chicks start to appear at nesting colonies. The nestling stage lasts for about 53 days and young fulmars fledge in mid-September (Nettleship et al. 1979). During the latter part of summer, large numbers of fulmars gather along the southeast coast of Ellesmere Island and the east and southeast coasts of Devon Island. Concentrations are much higher at glacier fronts than along regular coastlines (McLaren and Renaud 1979). This buildup usually begins in late July, but may be delayed to mid-August if fast ice persists into August (McLaren and Renaud 1979). Peak numbers occur in late August and early September along southeast Devon Island, and in mid-September along Ellesmere Island (Fig. 2.7.5). On 5-6 September 1976, an estimated 34,000 fulmars were present along the coast of Devon Island between Philpots Island and Croker Bay; on 21 September 1978, over 5,000 were counted along the southeast coast of Ellesmere Island (Johnson et al. 1976a; McLaren and Renaud 1979). The age composition and breeding status of these large concentrations is unknown. However, it is probable that breeding adults, failed nesters, and non-breeding subadults are all represented. A large proportion of the birds present along the south coast of Devon Island in August 1978 were moulting birds (M.S.W. Bradstreet, pers. comm.), which suggests that they were either failed nesters or subadults.

The distribution of fulmars changes markedly from June-July to August-September. Fulmars are common and widespread along most coasts and fast ice edges in the region in June and early July. However, in late August and September large numbers concentrate in small areas, especially along Devon

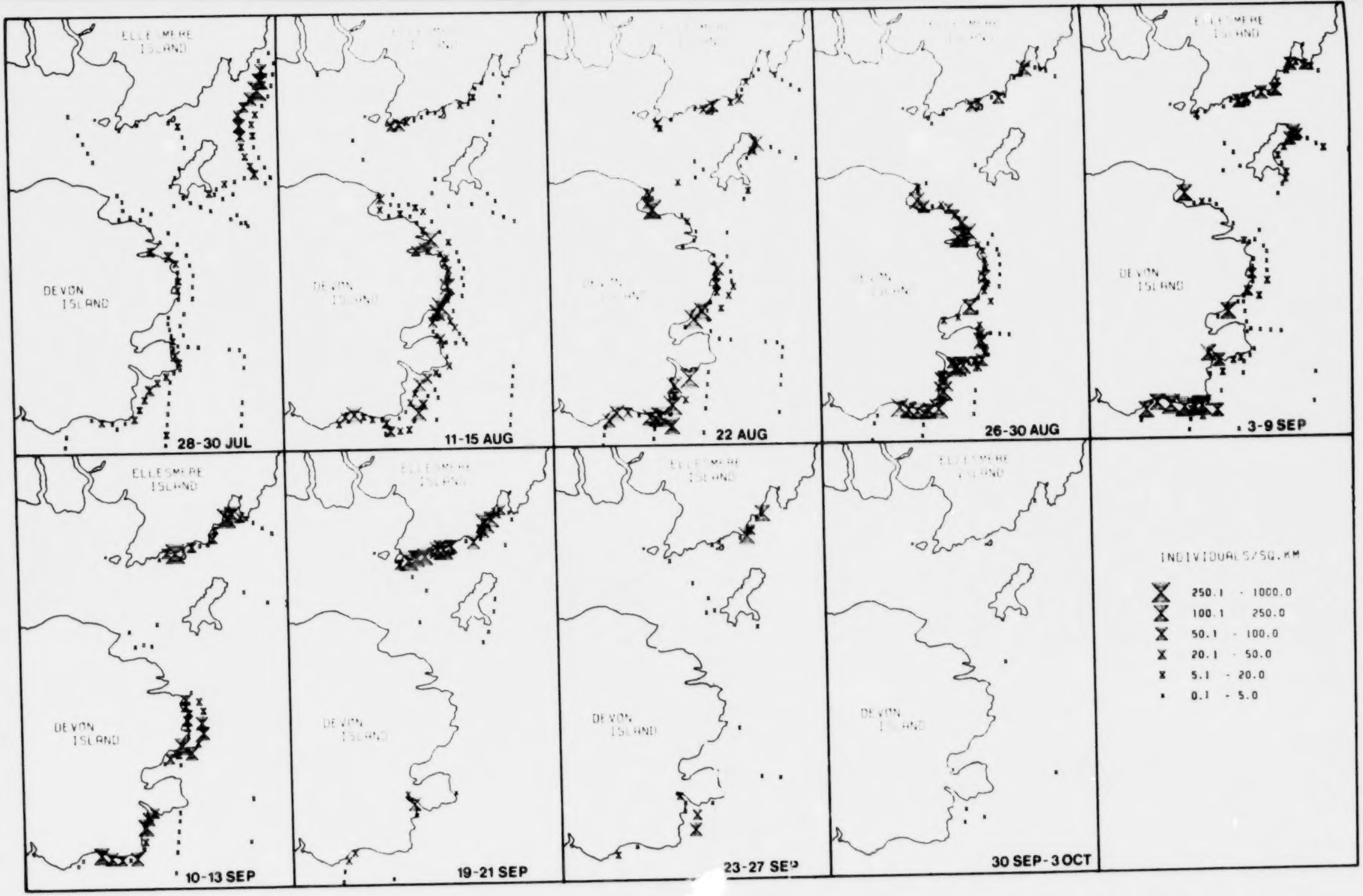

ELLESMERE ISLAND
DEVON ISLAND
28-30 JUL
11-15 AUG
22 AUG
26-30 AUG
3-9 SEP
10-13 SEP
19-21 SEP
23-27 SEP
30 SEP-3 OCT
INDIVIDUALS/SQ.KM
250.1 - 1000.0
100.1 250.0
50.1 - 100.0
20.1 - 50.0
5.1 - 20.0
0.1 - 5.0

FIG. 2.7.5. Northern fulmar distribution along Devon and Ellesmere islands 28 July-3 October 1978. Densities shown are for two-min (~ six km) transect segments. From McLaren and Renaud (1979).

and Ellesmere islands. In 1978, thousands of fulmars were also noted at headlands on the northeast and east coasts of Bylot Island and east of the village of Pond Inlet in early September. Fulmars are also common in Buchan Gulf and Scott Inlet, the two colony sites on northeast Baffin Island, at this time. Fulmars are also widespread offshore in late summer, although densities are substantially lower than those recorded in June and early July (Johnson et al. 1976a; McLaren and Renaud 1979).

Southward migration of fulmars begins in mid-September. Estimated numbers of fulmars present in Lancaster Sound decreased by over 80 percent between 13 and 19 September 1976 (Johnson et al. 1976a). In 1978, over 10,000 were estimated to be present in eastern Lancaster Sound and northwest Baffin Bay on 23-27 September, but by the beginning of October fewer than 1000 remained (McLaren and Renaud 1979). Southward migration occurs both along coasts and in offshore areas. Some fulmars may remain in Baffin Bay until forced to move south by freeze-up.

Northern fulmars are long-lived birds, with a mean adult life expectancy of about 34-36 years (Dunnet and Ollason 1977, 1978) and a low annual rate of reproduction. Only one egg is laid annually per pair, and only half of the eggs produced fledged young at Prince Leopold Island in 1975 (Nettleship 1977). Moreover, adverse climatic or other conditions may prevent a large majority of the population from nesting in a particular year. The average age of first breeding by fulmars is 9.2 years at a boreal colony (Ollason and Dunnet 1978). This delayed maturity and the low annual production of young imply that impacts affecting only a single year's production of young will probably have a relatively small effect on the overall population size. However, impacts affecting breeding adults could have severe, long-lasting effects on population size (Drury 1979; Dunn 1979).

Although non-breeding subadult fulmars (ages one to eight years) appear in the eastern Lancaster Sound-western Baffin Bay area in summer, their distribution is generally poorly known. Nettleship (pers. comm.) estimated that 40 percent of the fulmars present at the Prince Leopold Island colony in 1976 were non- breeders, but the ages of these birds were unknown. They occupied cliff ledges, perhaps in preparation for nesting in the following year. Salomonsen (1967) found that one- and two-year old fulmars did not return to the vicinity of their natal colony in the Umanak District of West Greenland; some three-year olds and many four-year olds returned to the area but it is not known if they occupied the nesting colony. It is probable, however, that significant numbers of four- to eight-year old subadult fulmars are present in the region in the summer. Thus at least a portion of the subadults (as well as the adults) might be susceptible to impacts within the study area.

2.7.2 Oldsquaw

The oldsquaw (Clangula hyemalis) is a common nesting resident in suitable lowland habitat throughout the Canadian Arctic, including the islands bordering the eastern Lancaster Sound-western Baffin Bay area (Tuck and Lemieux 1959; Godfrey 1966; Hussell and Holroyd 1974; Renaud et al. 1981). Individuals that nest in the area, winter in open water off the south and west coasts of Greenland and the east coast of Canada and the United States (Bellrose 1976; Palmer 1976).

Oldsquaws have been observed in the eastern Lancaster Sound-western Baffin Bay area as early as 10 May (Johnson et al. 1976a), but only small numbers are present prior to June (McLaren and McLaren 1982). The numbers moving into and through the region reach a peak in mid-or late June. In 1976, peak densities were recorded in Lancaster Sound on 20-21 June, and over 5,000 were seen in the same area on 27-28 June. In 1978, peak numbers and densities were recorded along the coasts of the area on 19-23 June (McLaren and Renaud 1979), and in 1979 the peaks, in the same areas as 1978, were on 10-11 June (McLaren 1980). In late June, numbers decrease sharply as oldsquaws move inland to nesting areas.

During the movement into and through the region, oldsquaw distribution is directly related to ice conditions. Oldsquaws require shallow coastal areas for feeding and are rarely seen in offshore areas or along offshore fast ice edges. Oldsquaws were common along the shores of eastern Lancaster Sound in June of both 1976 and 1979, but few were seen in these areas in 1978. Their virtual absence from this area in 1978 was attributable to the presence of extensive shelves of landfast ice along south Devon Island and north Bylot Island; this ice was not present in 1976 or 1979. In 1978 the fast ice apparently displaced oldsquaws to the north Devon Island-Coburg Island area, where shallow, ice-free coasts were present (McLaren and McLaren 1982).

Oldsquaws remain in coastal waters until their terrestrial nesting areas are free of snow. Nesting is generally underway by late June and early July, and few oldsquaws remain in marine areas by the end of June.

The incubation period of nesting oldsquaws is about 26 days (Alison 1975). During this period, generally much of July, few nesting females are present in coastal areas. However, breeding males, non-breeding adults and pre-breeding yearlings begin to moult in mid-July. During moult, the birds become flightless for a period of three to four weeks. Moulting areas include lakes or shallow sheltered coastal areas (Snyder 1957; Alliston et al. 1976; McLaren 1978). Throughout the last half of July, the numbers of birds in coastal areas steadily increase as more and more oldsquaws begin their moult.

Moulting of oldsquaws continues from mid-July until September. In terms of numbers, the peak of moult appears to be in the last week of August and first week of September. One of the most important areas is the southwest coast of Bylot Island, where the oldsquaw is also a common nesting species. Almost 3,000 moulters were seen along this coast on 28 August 1978. However, flocks of moulting birds also occur regularly along the south and east coasts of Devon Island, in sheltered bays on the northwest, north and southeast coasts of Bylot Island, and along low-lying coasts of northeast Baffin Island (Fig. 2.7.6). Between 30 July and 24 September 1978, almost 25,000 moulting oldsquaws, including over 7,200 seen during a survey on 3-9 September, were counted along the coasts of these three islands (McLaren and Renaud 1979).

Young-of-the-year oldsquaws are capable of flight when about 35 days old (Alison 1975). Young move to the sea in late August or early September while still flightless, with or shortly after nesting females. Consequently, many of the large flocks of oldsquaws present in September may include moulting females as well as recently fledged juveniles.

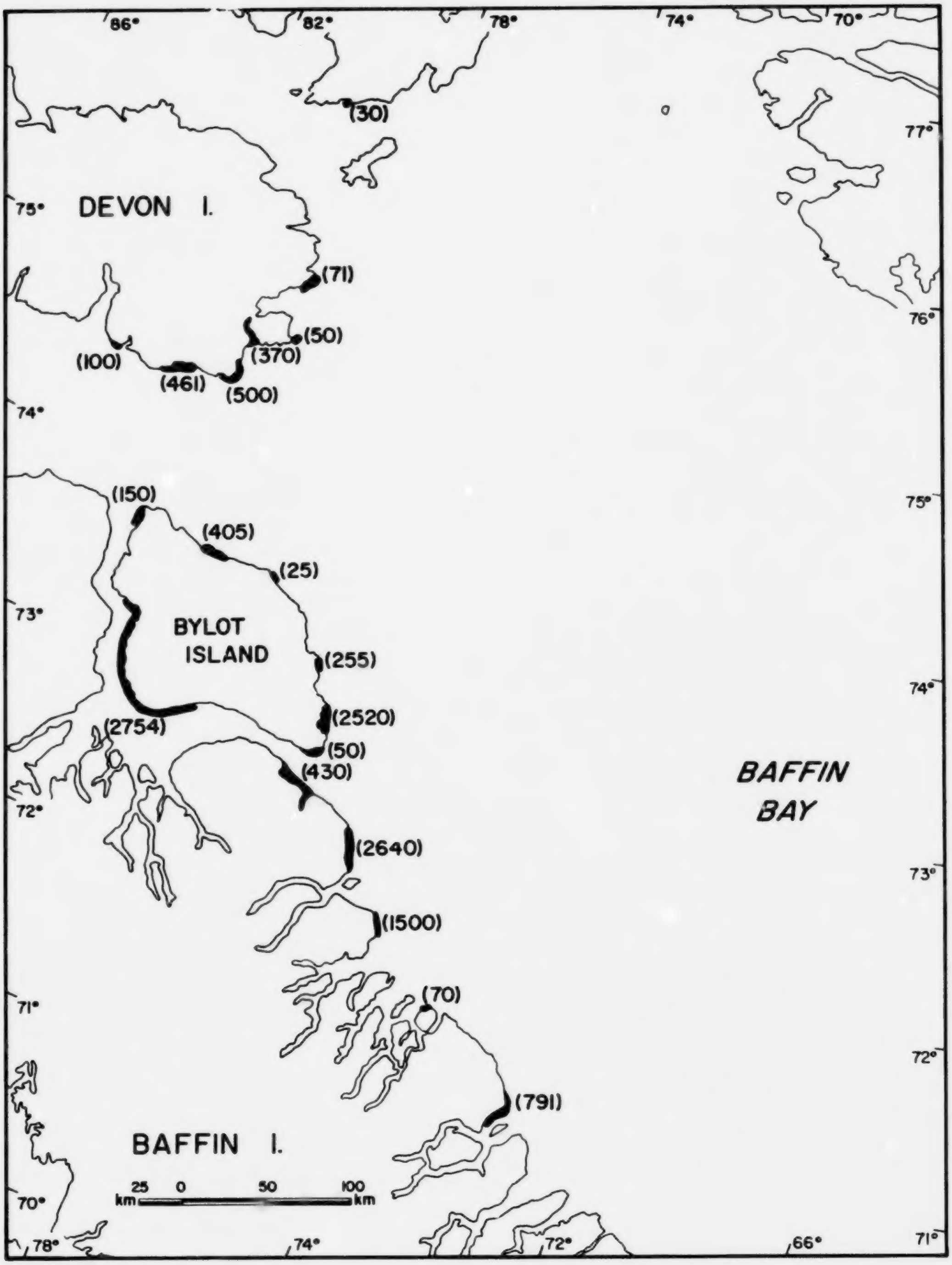

86°
82°
78°
74°
70°
77°
75°
DEVON I.
(30)
(71)
(50)
(370)
(100)
(461)
(500)
76°
74°
75°
(150)
(405)
(25)
73°
BYLOT
ISLAND
(255)
74°
(2520)
(2754)
(50)
(430)
BAFFIN
BAY
72°
(2640)
73°
(1500)
71°
(70)
72°
(791)
BAFFIN I.
25 0 50 100
km km
70°
78°
74°
72°
66°
71°

FIG. 2.7.6 Oldsquaw moulting areas in the eastern Lancaster Sound-western Baffin Bay area. Each number represents the maximum recorded at the location at one time. Data from Johnson et al. (1976a); McLaren and Renaud (1979).

By mid-September, many oldsquaws, particularly males, have left for wintering areas. However, flocks of up to several hundred birds remain in the eastern Lancaster Sound-western Baffin Bay area in late September and October. Distribution at this time is governed by local ice conditions. For example, few oldsquaws remain along the south and west coasts of Bylot Island in late September and October, because these areas are usually frozen.

In late September and October, oldsquaws tend to be most numerous in central and southern parts of the area. Over 4,600 were recorded along the shorelines of eastern Lancaster Sound on 26 September 1976 (Johnson et al. 1976a). Few were seen in this area on the same date in 1978 but over 5,700 were counted along the east coast of Baffin Island south of Pond Inlet on 25 September 1978 (McLaren and Renaud 1979). This area also contained 5300 oldsquaws on 26 September 1979 (LGL Ltd., unpubl. data). A few hundred were still present along this coast in mid-October 1979, but is unlikely that many remained in areas farther north. Small numbers of oldsquaws probably remain in the Baffin Bay area until forced to move south by freeze-up.

Like other species of arctic waterfowl, oldsquaws are susceptible to the effects of delayed snow and ice melt associated with periodic late springs in the arctic. In an extremely late year, many pairs do not attempt to nest at all, and consequently there is little or no production of young in that season. In many areas of the Canadian high arctic no nesting occurred in 1972 and 1974 (Davis et al. 1974), and in 1976 and 1978 (LGL Ltd., unpubl. data). During such years, oldsquaws may spend proportionally more time in marine waters than in years of successful nesting (Alliston et al. 1976).

2.7.3 Eiders

Two species of eider ducks occur in the eastern Lancaster Sound-western Baffin Bay area: the common eider (Somateria mollissima) and the king eider (S. spectabilis). Both are holarctic in distribution and are widespread in the Canadian Arctic (Godfrey 1966). Common eiders occur in large numbers west to at least Bathurst Island (McLaren and Alliston MS), but nest only in suitable habitat along coastlines eastward from Cornwallis Island (Godfrey 1966). The king eider is considerably more abundant than the common eider (Bellrose 1976; McLaren and Alliston MS) and nests in lowland habitat throughout the islands of the east and central high arctic (Godfrey 1966). Eider populations that summer in this region probably winter in coastal waters of southwest Greenland and northeast North America (Salomonsen 1950, 1968; Bellrose 1976; Palmer 1976). Migration routes into the region are thought to follow the coast of Greenland north to the Thule District and thence across to Coburg Island, and along the edge of the fast ice off the east coast of Baffin Island (McLaren and McLaren 1982).

Eiders first return to the eastern Lancaster Sound-western Baffin Bay area in late April. King eiders have been observed in Lancaster Sound as early as 22 April (Horring 1937) and in 1978 they were present along the fast ice edge across eastern Lancaster Sound by 25 April (McLaren and Renaud 1979). Common eiders have been reported in Lancaster Sound on 2 May (Johnson et al. 1976a). The first species to return in large numbers, usually about mid-May, is the king eider. In both 1978 and 1979, upwards of 22,000 king eiders were present in the shallow coastal areas along Coburg Island in the second week of May. Common eiders appear there slightly later than the king eiders and their numbers are substantially fewer. Most of the eiders present at this time are in flocks of pairs.

Numbers of eiders in the eastern Lancaster Sound-western Baffin Bay area increase throughout the remainder of May. Some king eiders migrate north along the landfast ice edge bordering east Baffin Island (McLaren and Renaud 1979; McLaren 1980). Enormous mixed flocks of king and common eiders, including both males and females, occur at headlands along the north and east coasts of Devon Island where ice has receded back to the coastline. These flocks persist into early June when numbers begin to decrease. Flocks totalling about 17,000 eiders have been seen in these areas (McLaren and Renaud 1979).

In late May and early June of 1978 and 1979, eider densities and numbers around Coburg Island decreased sharply. This decrease occurred about the same time that large numbers began to occur along the shorelines of Lancaster Sound, especially along southeast Devon Island. In 1976, 1978 and 1979, peak numbers were recorded in Lancaster Sound during early June (Fig. 2.7.7). Part of this peak is due to the arrival of large numbers of common eiders, whose major migration into the region is about two to three weeks later than that of king eiders (McLaren and Renaud 1979); however, much of it is also probably due to the movement of eiders from staging areas at Coburg Island through Lancaster Sound to nesting areas in the central arctic.

Peak numbers of eiders seen in Lancaster Sound were much lower in 1978 than in either 1976 or 1979 (Fig. 2.7.7). This difference was undoubtedly due to the presence of shelves of landfast ice extending several kilometres off the south coast of Devon Island and the north coast of Bylot Island in 1978. Eiders require shallow coastal areas for feeding and the absence of these areas in Lancaster Sound in 1978 meant that eiders could not feed there as they did in 1976 and 1979. Indeed, the more than 14,000 eiders counted near King Edward VII Point, Ellesmere Island, on 19 June 1978 may have been a result of displacement from other parts of the study area to one of the few ice-free, shallow water sites in the study area.

During their migration into the area, eiders occur almost exclusively along coasts and fast ice edges. Numbers in offshore areas are insignificant. Even along these interfaces, eiders prefer ice-free shorelines to fast ice edges, a result of their shallow water feeding habits. Consequently, during May and early June, the largest concentrations of eiders are in those areas where ice edges have receded to the coastlines.

During June, eiders are common throughout much of the region. Distributions may vary, however, probably in response to ice conditions. In 1978, large flocks were seen regularly at ice-free headlands along northeast Devon Island (e.g. Fig. 2.7.8); in 1979, these headlands were not clear of ice until late June, and instead eiders concentrated along the ice-free east coast of Devon Island between Raper Point and Cape Parker, and along the south coast (Fig. 2.7.8). In late June, eider densities and numbers become much lower as birds that have been staging or resting in coastal waters begin to move inland to nesting areas. Numbers counted in coastal waters decreased from over 40,000 on 19-20 June 1978 to 12,000 on 26 June (McLaren and Renaud 1979) and from 21,000 on 19-23 June 1979 to 9000 on 28 June-1 July (McLaren 1980).

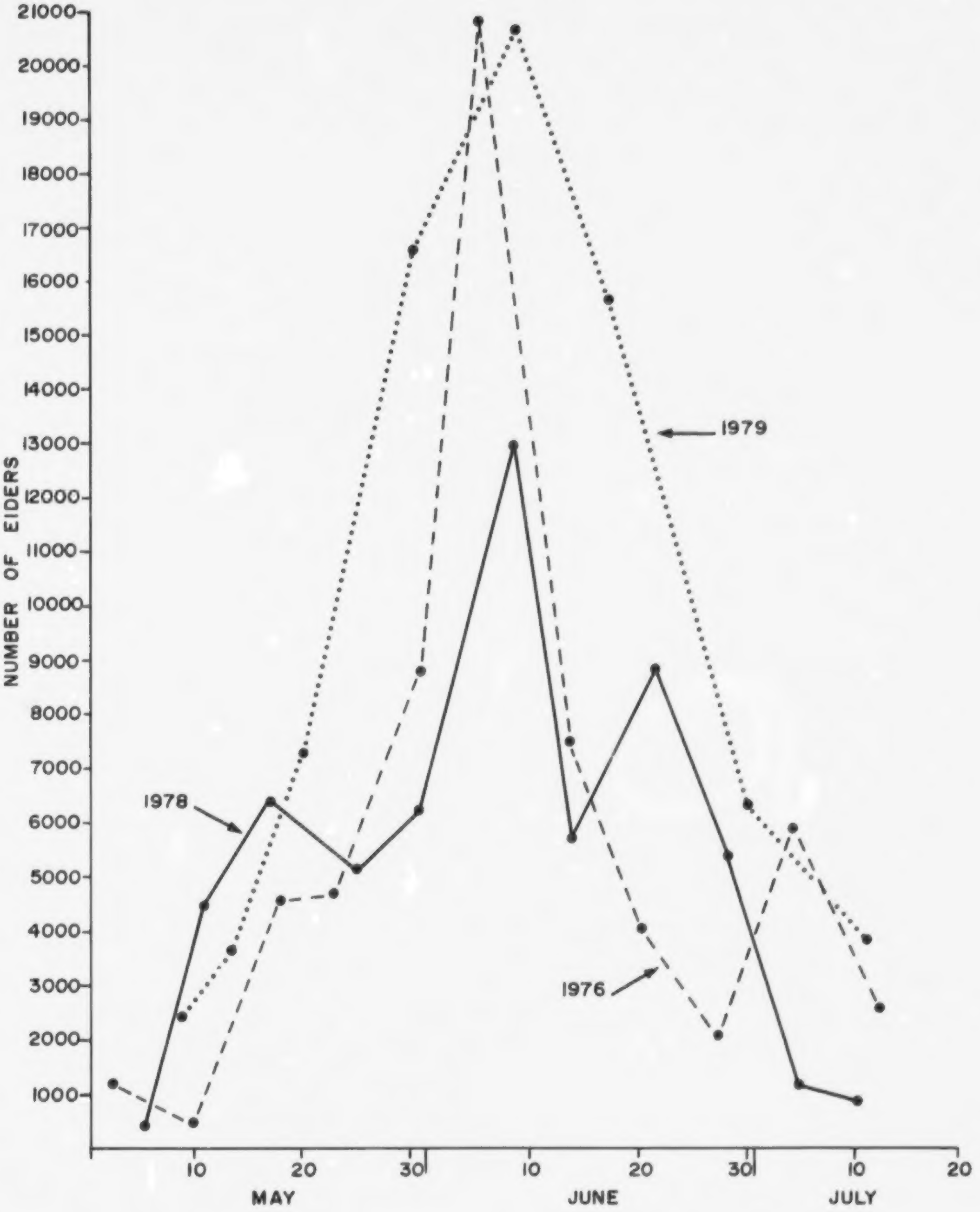


FIG. 2.7.7 Numbers of eiders observed during aerial surveys in eastern Lancaster Sound, May-July 1976 (Johnson et al. 1976a), 1978 (McLaren and Renaud 1979) and 1979 (McLaren 1980).

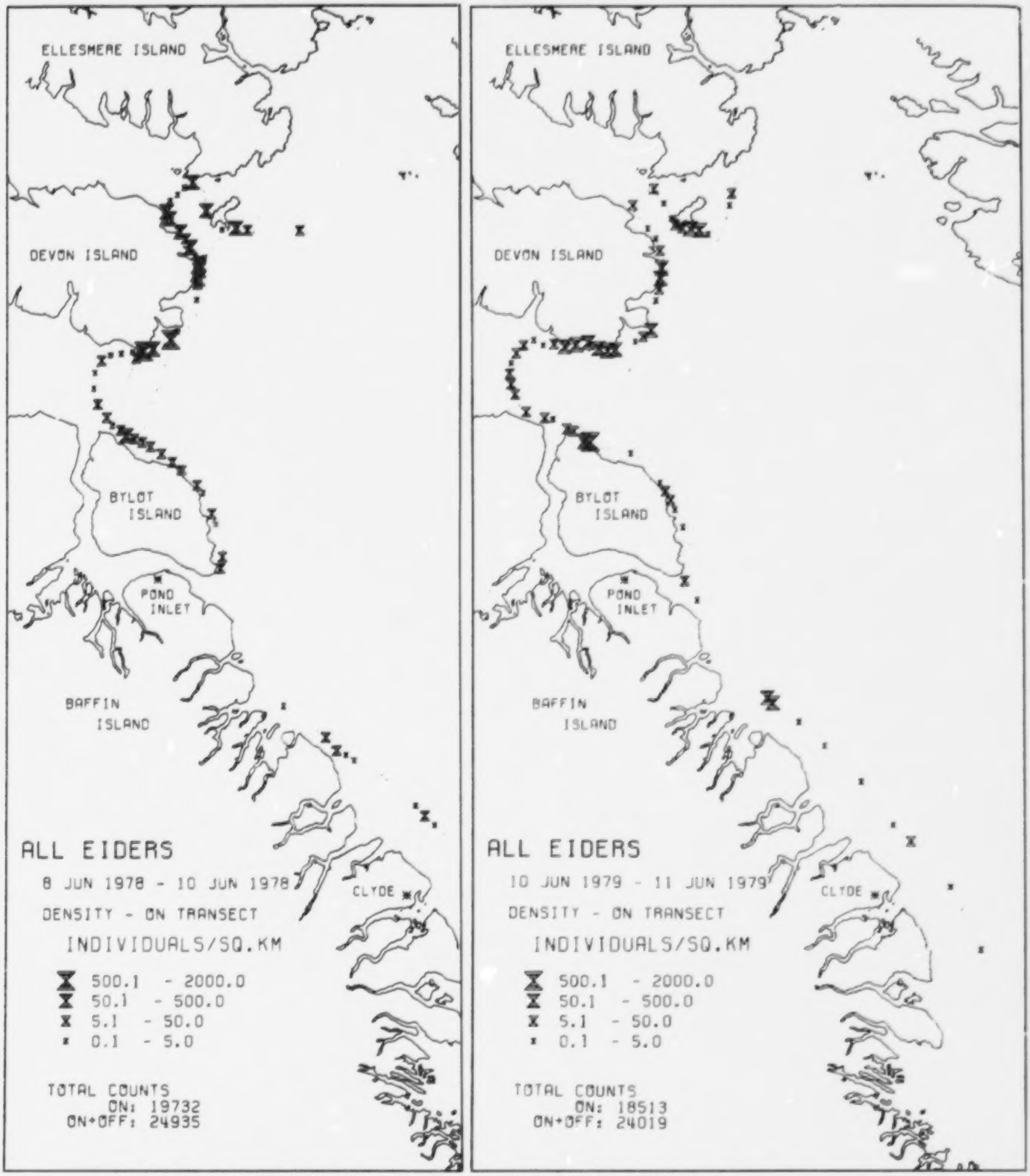

ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
ALL EIDERS
8 JUN 1978 - 10 JUN 1978
DENSITY - ON TRANSECT
INDIVIDUALS/SQ.KM
500.1 - 2000.0
50.1 - 500.0
5.1 - 50.0
0.1 - 5.0
TOTAL COUNTS
ON: 19732
ON+OFF: 24935
ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
ALL EIDERS
10 JUN 1979 - 11 JUN 1979
DENSITY - ON TRANSECT
INDIVIDUALS/SQ.KM
500.1 - 2000.0
50.1 - 500.0
5.1 - 50.0
0.1 - 5.0
TOTAL COUNTS
ON: 18513
ON+OFF: 24019

FIG. 2.7.8 Eider distribution in the study area, 8-10 June 1978 and 10-11 June 1979. Densities shown are for four-min (~12 km) transect segments. From McLaren and Renaud (1979); McLaren (1980).

Eiders begin to nest in late June or early July. King eiders tend to nest somewhat earlier than common eiders (Bellrose 1976). Incubation by king eiders lasts about 23 days, and by common eiders, about 25 days (Bellrose 1976). Shortly after nesting has begun, non-breeding birds and breeding males gather on coastal areas in preparation for migration to moulting areas. Most king eiders in the eastern Lancaster Sound-western Baffin Bay area are believed to moult in the Disko Bay area of west Greenland (Salomonsen 1968; Bellrose 1976). Moulting areas of common eiders are less well known, although Salomonsen (1979) suggested that the Clyde River area of east Baffin Island is a moulting area for females. An apparent gathering place for eiders prior to their moult migration is west of Cape Hay, on the northwest coast of Bylot Island. Johnson et al. (1976a) recorded 1,300 king eiders, mostly males, in a small bay there on 5 July 1976. Tuck and Lemieux (1959) noted more than 15,000 king eiders in this area in mid-July 1957. The actual migration is probably underway by late July. Although many hundreds of male king eiders were seen during surveys in late July 1976 and 1978, few were seen in early August of those years (Johnson et al. 1976a; McLaren and Renaud 1979). Common eider males had essentially vanished from the region by 15 August in those years. Female eiders, presumably including non-breeders, failed breeders and some breeders, undertake their moult migration in mid-August. Some of these birds probably come from areas in the central arctic where peak numbers of female eiders along coasts occur in the first 10 days of August (McLaren and Alliston MS). About 22,000 eider females were seen along the north and east coasts of Bylot Island on 12 August 1978 and about 7,700 female eiders were seen migrating east past Cape Hay, Bylot Island, on 17 August 1978 (McLaren and Renaud 1979).

Although male king eiders from nesting areas in southern parts of the arctic archipelago migrate east across Baffin Island (Wynne-Edwards 1952), most eiders leaving nesting areas in the central and east central parts of the Canadian arctic archipelago do so by way of Lancaster Sound, particularly along the south shore, and the east coasts of Bylot and Baffin islands. In late July and August of 1976 and 1978, densities were considerably higher in these areas than elsewhere in the region. There is no information on the summer migration route of eiders nesting in the northern parts of the region, but these birds may move south to the Bylot Island coast and then follow that coast and the Baffin Island coast south to moulting areas.

Although most males and non-nesting females moult outside the eastern Lancaster Sound-western Baffin Bay area, eiders do moult at some coastal locations within this area. Such areas include southern Ellesmere Island, southern Devon Island, Bylot Island, northeast Baffin Island, and (possibly) many of the fiords and inlets along eastern Baffin Island (Fig. 2.7.9). In 1978, over 2,200 moulting eiders, including almost 600 on 26-30 August, were seen in these areas in August and September. The great majority of these were females.

The favoured nesting habitat of the king eider is coastal lowlands; common eiders prefer small coastal islands (Bellrose 1976), although they will also nest in coastal lowlands (Hussell and Holroyd 1974). A small colony of common eiders was seen on islets off the east coast of Philpots Island during 1978 (M.S.W. Bradstreet, pers. comm.). These nesting requirements are reflected in the absence of broods along the east coast of Baffin Island. That coast is primarily composed of steep cliffs and headlands with few shallow areas, small islets, or coastal lowlands.

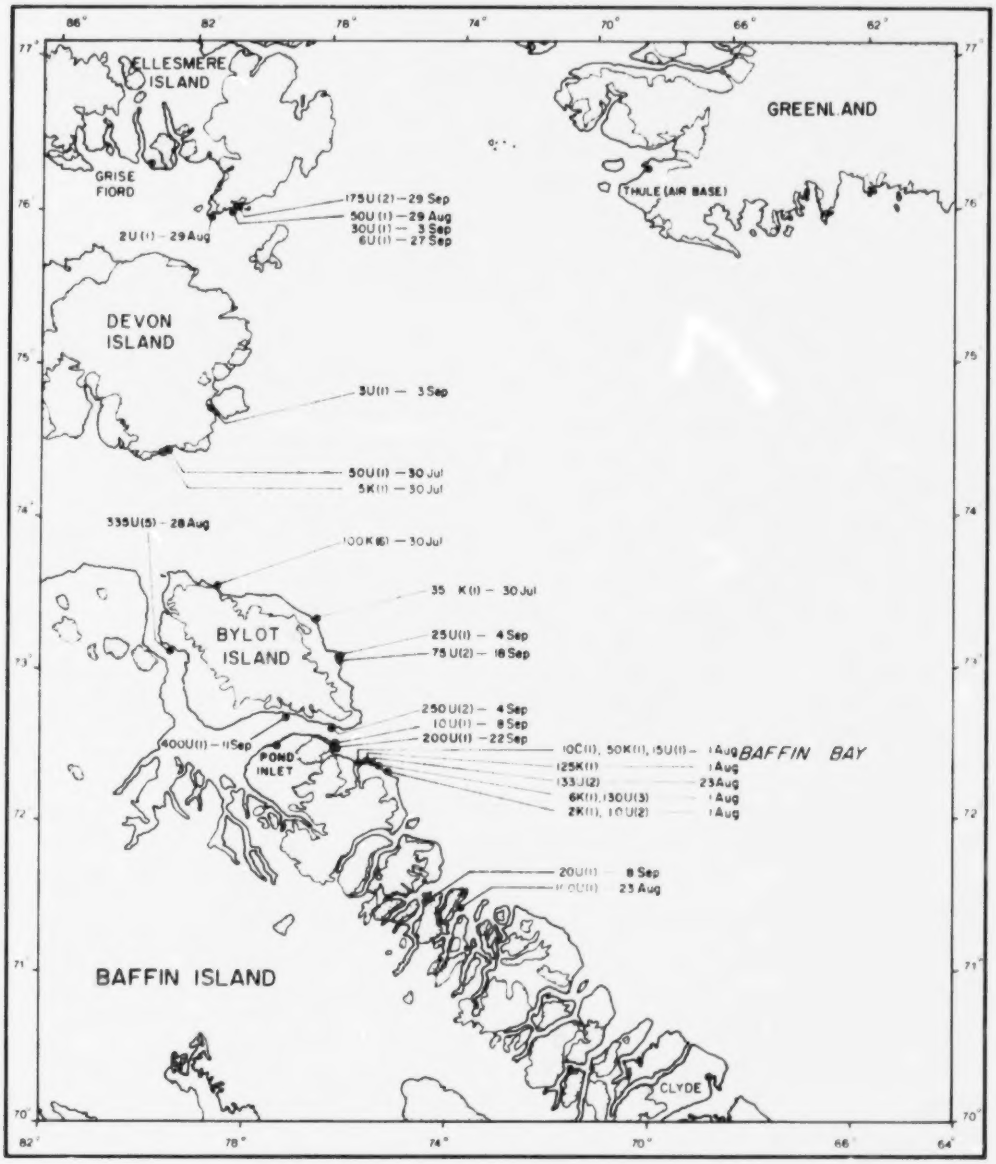

86°
82°
78°
74°
70°
66°
62°
77°
76°
75°
74°
73°
72°
71°
70°
ELLESMERE ISLAND
GRISE FIORD
GREENLAND
THULE (AIR BASE)
175U(2)—29 Sep
50U(1)—29 Aug
30U(1)— 3 Sep
6U(1)—27 Sep
2U(1) - 29 Aug
DEVON ISLAND
3U(1) — 3 Sep
50U(1) —30 Jul
5K(1) — 30 Jul
335U(5) - 28 Aug
100K(6) — 30 Jul
35 K(1) — 30 Jul
BYLOT ISLAND
25U(1) — 4 Sep
75 U(2) — 18 Sep
250U(2) — 4 Sep
10U(1) — 8 Sep
200U(1) —22 Sep
400U(1) — 11 Sep
POND INLET
10C(1), 50K(1), 15U(1) — 1 Aug
BAFFIN BAY
125K(1) 1 Aug
133U(2) 23 Aug
6K(1), 130U(3) 1 Aug
2K(1), 10U(2) 1 Aug
20U(1) 8 Sep
100U(1) 23 Aug
BAFFIN ISLAND
CLYDE
82°
78°
74°
70°
66°
64°

FIG. 2.7.9 Moulting areas of eiders, 30 July-29 September 1978. C = common eider, K = king eider, U = unidentified eider. "175 U(2) - 29 Sep" indicates a total of 172 unidentified eiders in two groups on 29 September. From McLaren and Renaud (1979).

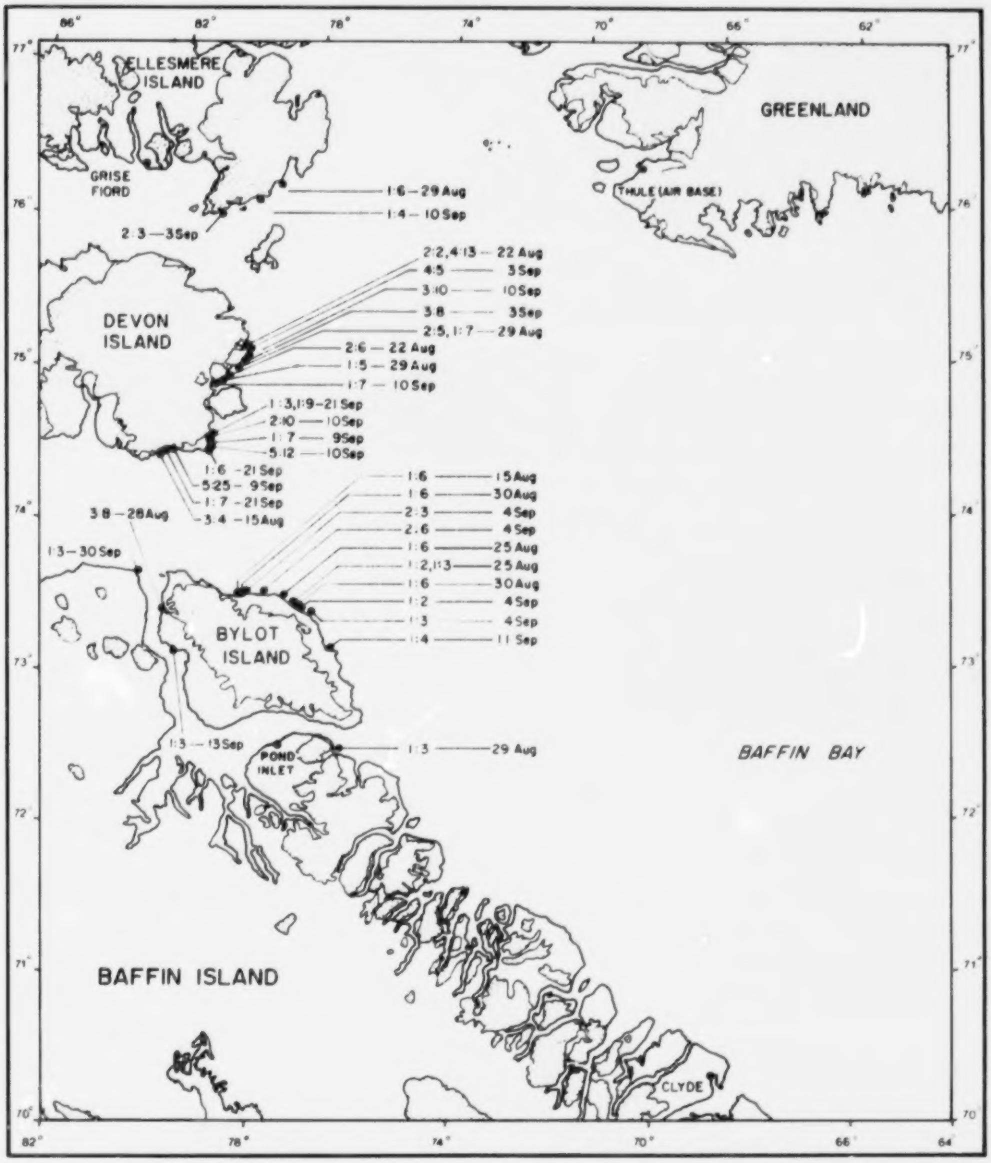

86°
82°
78°
74°
70°
66°
62°
77°
76°
75°
74°
73°
72°
71°
70°
64°
ELLESMERE ISLAND
GRISE FIORD
GREENLAND
THULE (AIR BASE)
1:6—29 Aug
1:4—10 Sep
2:3—3 Sep
DEVON ISLAND
2:2, 4:13—22 Aug
4:5—3 Sep
3:10—10 Sep
3:8—3 Sep
2:5, 1:7—29 Aug
2:6—22 Aug
1:5—29 Aug
1:7—10 Sep
1:3, 1:9—21 Sep
2:10—10 Sep
1:7—9 Sep
5:12—10 Sep
1:6—21 Sep
5:25—9 Sep
1:7—21 Sep
3:4—15 Aug
3:8—28 Aug
1:3—30 Sep
1:6—15 Aug
1:6—30 Aug
2:3—4 Sep
2:6—4 Sep
1:6—25 Aug
1:2, 1:3—25 Aug
1:6—30 Aug
1:2—4 Sep
1:3—4 Sep
1:4—11 Sep
BYLOT ISLAND
1:3—13 Sep
POND INLET
1:3—29 Aug
BAFFIN BAY
BAFFIN ISLAND
CLYDE

FIG. 2.7.10 Brood-rearing areas of eiders, 15 August-30 September 1978. "2:2-22 Aug." indicates a group of two adults with two young on 22 August. From McLaren and Renaud (1979).

Nesting female eiders rear their broods in coastal waters. Broods first appear in early August. Important brood-rearing areas include the east and south coasts of Devon Island and the northeast coast of Bylot Island (Fig. 2.7.10).

Eiders probably remain in the eastern Lancaster Sound-western Baffin Bay area well into October, although an early freeze-up of coastal areas may force them south sooner. Almost 700 eiders were counted on 7-10 October 1978; most could not fly and some may have been late broods. Most were seen along the southeast coast of Bylot Island and the east coast of Baffin Island (McLaren and Renaud 1979). In 1979, several hundred eiders were present along the east coast of Baffin Island at least as late as 17 October (LGL Ltd., unpubl. data).

Eiders may fail to nest in years with late thaws (Davis et al. 1974; Palmer 1976; McLaren et al. 1977). Such a situation may have occurred in 1978. In that year, only 37 broods containing 228 young were counted. During 1976, in contrast, 76 broods with 742 young were seen even though the surveyed area in 1976 was less than half as large as that in 1978. Moreover in 1976, 55 broods or brood flocks were counted along the south coast of Devon Island east of Cape Warrender, whereas in 1978, only nine were seen in the same area (Johnson et al. 1976a; McLaren and Renaud 1979). Eiders can also suffer heavy mortality in spring when shallow marine staging and resting areas remain ice-covered (Barry 1968; Palmer 1976), and breeding success can be low even in years with good weather conditions (Lamothe 1973).

2.7.4 Glaucous Gull

The glaucous gull (Larus hyperboreus) nests commonly throughout the Canadian Arctic (Godfrey 1966). Within the eastern Lancaster Sound-western Baffin Bay area, there are colonies along the east and south coasts of Devon Island; along the southeast, west and northwest coasts of Bylot Island; at Buchan Gulf, Baffin Island; and at Coburg Island and the Stewart Islands near southeast Ellesmere Island. Colonies range in size from 10 to 60 pairs. This species also nests commonly in the fiords along the south coast of Ellesmere Island, along the coasts of western Lancaster Sound and Barrow Strait, and along the west coast of Greenland (Salomonsen 1950; Nettleship 1974; Johnson et al. 1976a; McLaren and Renaud 1979). Glaucous gulls that summer in this region winter in south Davis Strait and the western North Atlantic Ocean.

Glaucous gulls probably return to the area in late April. They were present on 2 May 1976 and 4 May 1978, when surveys commenced (Johnson et al. 1976a; McLaren and Renaud 1979). Arrival of the northwest Greenland population at nesting areas occurs from late April to mid-May (Salomonsen 1950).

The numbers of glaucous gulls present in the area increase gradually through May. However, unlike those of many other species, numbers do not seem to increase abruptly at any one time. Rather, individuals migrate steadily into the area and onward to nesting sites. By early June, most colony sites are likely to be occupied by breeding adults. During migration in May and June, densities remain fairly constant at about one-two birds/km^2 along coasts and ice edges. The vast majority of glaucous gulls are found along these interfaces and densities are significantly higher along coasts than fast ice edges. Glaucous gulls are rarely seen offshore; the average density offshore in May and June 1978 was one bird/100 km^2 (McLaren and Renaud 1979).

Glaucous gulls are widely distributed throughout the region during migration and may occur anywhere from central Baffin Island north to Ellesmere Island. There are, however, certain coastal areas where concentrations occur. Such areas include the south coast of Coburg Island and along the fast ice edges to the east and west of the island. More than 600 birds were counted in this area on 21 May 1979 (Fig. 2.7.11). These individuals presumably nest on colonies at Coburg Island, on the Stewart Islands, and along the south coast of Ellesmere Island. Concentrations of glaucous gulls are also frequently present near Raper Point, on the east side of Devon Island--almost 200 birds were seen there on 21 May 1979--and along the northwest coast of Bylot Island--100 birds were seen there, also on 21 May 1979 (McLaren 1980). Both areas are sites of nesting colonies. Glaucous gulls are also common along the fast ice edge across the mouth of Pond Inlet. Almost 200 were seen there on 14 May 1978 and on 22 May 1979 (McLaren and Renaud 1979; McLaren 1980). These birds frequently scavenge at the offal of hunter-killed marine mammals. They probably nest at a colony north of Cape Graham Moore, on the southeast coast of Bylot Island.

Glaucous gulls start nesting in late May or early June. The incubation period is 27 or 28 days and eggs hatch in late June and July. Young are in the nest for about 50 days and fledging occurs from mid-August to early September (Salomonsen 1950; Godfrey 1966). Glaucous gulls are widely distributed along the coasts and fast ice edges of western Baffin Bay and eastern Lancaster Sound during the nesting period. Generally, densities and distribution during much of June are similar to those noted during May.

In early to mid-July, large numbers of glaucous gulls appear along the south coast of Devon Island. Almost 500 were present on 19 July 1976 (Johnson et al. 1976a) and similar numbers were present regularly in this area through mid-August. Some of the birds that appear along the coast at this time of year are undoubtedly locally nesting individuals, but some are possibly non-breeding immature birds that may move into the area after nesting is well underway. As well, hundreds of glaucous gulls appear along the west coast of Bylot Island and the south shore of Pond Inlet in late July, after the fast ice has left these inlets (McLaren and Renaud 1979).

The presence of the fast ice edge across Lancaster Sound in 1978 and 1979 may have affected the distribution of this species in the sound. The occurrence of the edge resulted in the presence of flocks of glaucous gulls in an area where they would not ordinarily occur--in the middle of Lancaster Sound. The ice also effectively eliminated coastal marine habitat everywhere west of the ice edge. In 1976, when no fast ice edge was present, the average density along the coasts of Lancaster Sound from early May to the end of June was 0.6 birds/km^2 (LGL Ltd., unpubl. data). In 1978 and 1979, the corresponding values were 1.1 and 2.3 birds/km^2, respectively (McLaren and Renaud 1979; McLaren 1980). These differences suggest that in the last two years, glaucous gulls that might ordinarily have been widely distributed along coasts throughout the whole of Lancaster Sound and east Barrow Strait were forced to concentrate in the easternmost portion of the sound because of

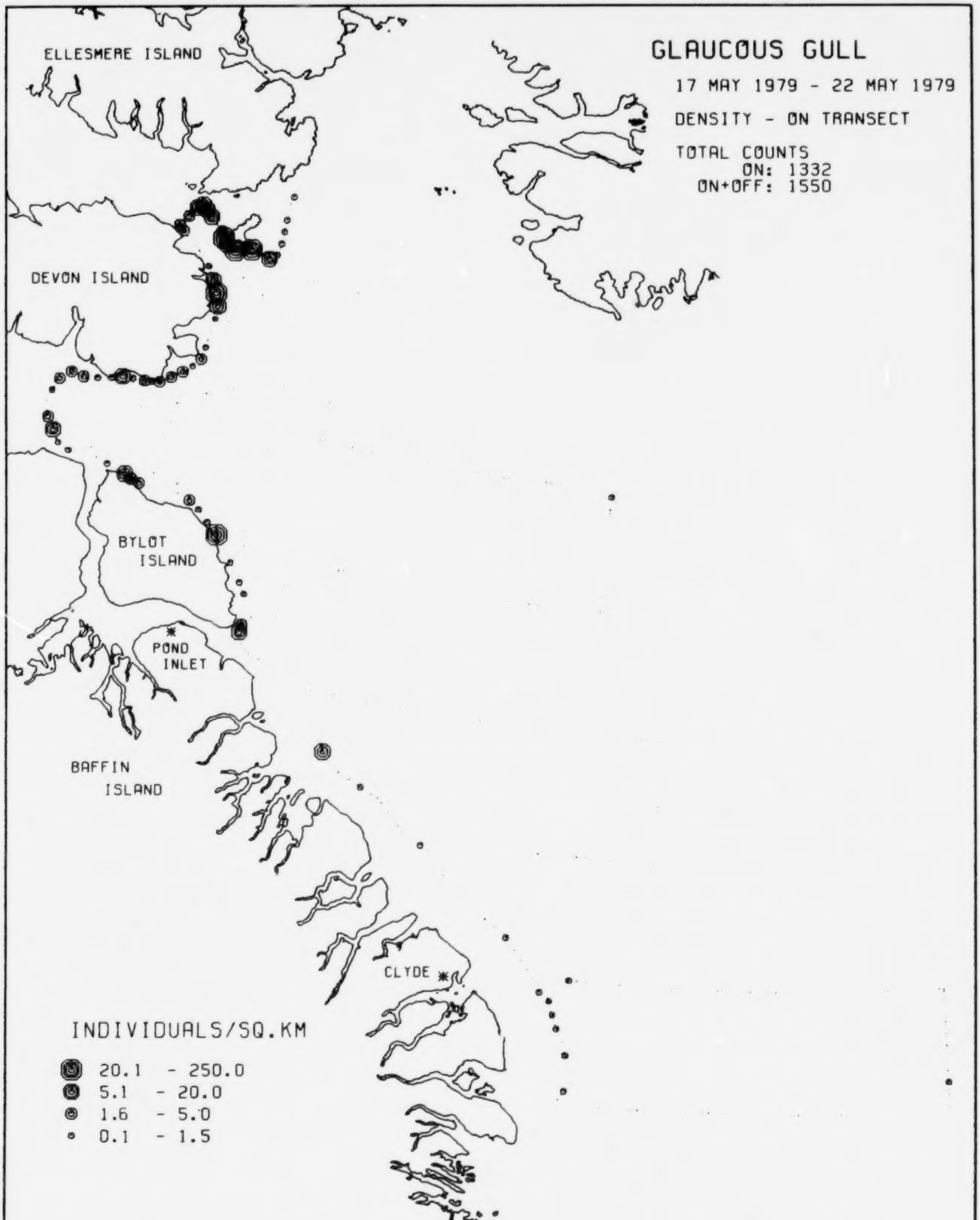

ELLESMERE ISLAND
GLAUCOUS GULL
17 MAY 1979 - 22 MAY 1979
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 1332
ON+OFF: 1550
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
INDIVIDUALS/SQ.KM
20.1 - 250.0
5.1 - 20.0
1.6 - 5.0
0.1 - 1.5

FIG. 2.7.11 Glaucous gull distribution in the study area, 17-22 May 1979. Densities shown are for four-min (~ 12 km) transect segments. From McLaren (1980).

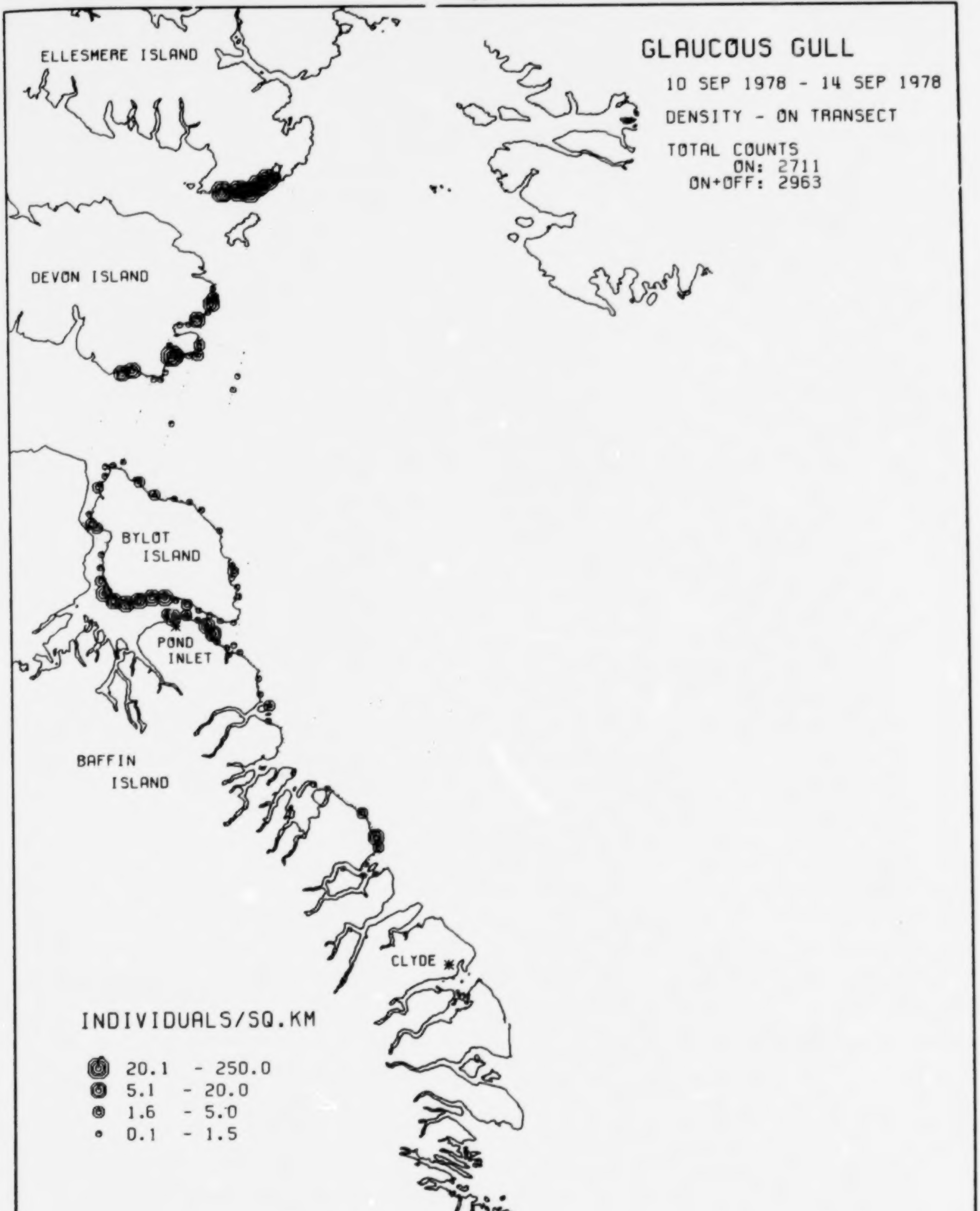

ELLESMERE ISLAND
GLAUCOUS GULL
10 SEP 1978 - 14 SEP 1978
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 2711
ON+OFF: 2963
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
INDIVIDUALS/SQ.KM
20.1 - 250.0
5.1 - 20.0
1.6 - 5.0
0.1 - 1.5

FIG. 2.7.12 Glaucous gull distribution in the study area, 10-14 September 1978. Densities shown are for four-min (~12 km) transect segments. From McLaren and Renaud (1979).

the absence of habitat west of the ice edge. The difference between densities along the margins of Lancaster Sound in 1978 and 1979 may be attributable to the extensive shelves of fast ice that extended several kilometres off the coasts of both Devon and Bylot islands in 1978. In 1979 both the south coast of Devon Island and the northwest coast of Bylot Island were virtually ice-free.

The numbers of glaucous gulls in the region continue to increase in August and September. In 1976, about 2,300 were estimated to be in eastern Lancaster Sound, or three times as many as in May and June (Johnson et al. 1976a). From 21 August to 4 October 1978, the average density of glaucous gulls along coasts north of Scott Inlet, Baffin Island, was about five times higher than the average from early May to mid-August (McLaren and Renaud 1979). Numbers increase gradually through late August to a peak in mid-September (Fig. 2.7.12). This increase in numbers may be attributable to an influx of non-breeding subadult gulls plus a post-breeding dispersal of breeding adults and young-of-the-year. Most of the latter fledge by early September.

During this period, glaucous gulls consistently concentrate in certain areas: the southeast coast of Ellesmere Island, where several thousands were present in September 1978 (peak of more than 4,400 individuals on 21 September); southwest of Philpots Island, where many hundreds are present in September and October (including almost 1,800 in Bethune Inlet on 3 October 1978); and the south coast of Devon Island east of Croker Bay, where more than 1000 glaucous gulls were seen on 5 September 1976 (Johnson et al. 1976a). At each of these sites densities were higher in front of glaciers than along adjacent coastlines.

Large concentrations of glaucous gulls also occur in coastal areas of Navy Board Inlet, Eclipse Sound and Pond Inlet, from late August to late September. Almost 900 gulls were along the west coast of Bylot Island on 9 September 1978, and 700 were seen along the south shore of Pond Inlet on 26 September 1978. Farther to the south, along the east coast of Baffin Island, glaucous gulls are much less numerous, although over 1,300 were seen in the area of Buchan Gulf on 4 October 1979 (McLaren and Renaud 1979; LGL Ltd., unpubl. data).

Migration of glaucous gulls from the area probably begins in mid- to late September. Johnson et al. (1976a) noted a decrease in numbers in Lancaster Sound in late September 1976. Adults leave somewhat earlier than the young-of-the-year. Virtually all glaucous gulls seen in 1978 after 7 October were young-of-the-year (McLaren and Renaud 1979). The proportion offshore is substantially higher at this time than earlier in the year, although the birds are very widely and sparsely distributed. A few glaucous gulls probably remain in the region until forced to move south by freeze-up in late October or early November.

2.7.5 Ivory Gull

The ivory gull (Pagophila eburnea) is a high arctic circumpolar species, restricted at most times of year to ice-rich seas. It is considered to be rare (MacDonald 1979), although this categorization may be partly a function of its very remote range, and the difficulty of censusing populations in high arctic areas. Until 1977, when five small colonies were found on southeast

Ellesmere Island (Frisch and Morgan 1979), ivory gulls were known to have nested at only five locations in the Canadian Arctic and northwest Greenland (Salomonsen 1950; MacDonald 1976).

In winter, ivory gulls disperse widely over pack ice, often far south of their nesting localities. In eastern Canada, they occur along the edge of pack ice in Davis Strait (MacLaren Marex Inc. 1979c), and along the coasts of Labrador and Newfoundland (Godfrey 1966).

Ivory gulls probably do not winter in the eastern Lancaster Sound-western Baffin Bay area (Renaud and Bradstreet 1980). The first individuals return to the southern parts of the region in mid-May and numbers increase steadily thereafter (McLaren and Renaud 1979; McLaren 1980). By late May they are widely distributed throughout the region. Migration continues throughout June, with a peak around 20-23 June. During a survey on 19-23 June 1979, an estimated 1,600 ivory gulls were offshore in Baffin Bay, primarily in the southernmost surveyed portions, and an additional 140 were seen along the coasts and ice edges in the area (McLaren 1980). During migration, concentrations of ivory gulls occur frequently along ice edges northeast of Coburg Island, across Pond Inlet and Lancaster Sound, and east of Baffin Island (McLaren 1980).

In late June, numbers and densities in the area decrease substantially, possibly as birds move north and west to summering areas. However, the presence of ivory gulls in offshore Baffin Bay from June to August (McLaren and Renaud 1979) indicates that many non-nesting birds pass the summer there.

From mid-August through early October, flocks of up to several hundred ivory gulls appear along coastlines in the eastern and central arctic archipelago (Renaud and McLaren 1982). In 1978, over 350 ivory gulls were seen along northeast Devon Island on 3 September, and almost 400 were in Bethune Inlet, south of Philpots Island, on 3 October (McLaren and Renaud 1979). The age composition of these flocks is not known, but may include adults, subadults and young-of-the-year. These concentrations occur most frequently along the fronts of glaciers, presumably in response to the presence of an abundant food source that is less numerous, or less accessible, elsewhere. Large flocks also occur near settlements, usually feeding at offal of whales and seals.

In late September and early October, numbers of ivory gulls in offshore waters begin to increase as numbers seen along coasts decrease. This apparent movement from coastal to offshore waters is presumably the initial stage of a migration southward to wintering areas, and is probably related to the increasing amount of pack ice present offshore; numerous authors have noted an association between pack ice and ivory gulls (Divoky 1972; Watson and Divoky 1972; Renaud and McLaren 1982). Ivory gulls probably remain in Baffin Bay until forced to move south by freeze-up.

2.7.6 Black-legged Kittiwake

The black-legged kittiwake (Rissa tridactyla) is common in the eastern Lancaster Sound-western Baffin Bay area. There are, in this region, four nesting colonies consisting of about 50,000-55,000 breeding pairs (Fig. 2.7.2); there are also several colonies west of Lancaster Sound, totalling about 35,000 pairs (Brown et al. 1975; Alliston et al. 1976; Nettleship and Gaston 1978). Birds from all these colonies would be expected to pass through eastern Lancaster Sound and Baffin Bay during migration. There are also several nesting colonies along the west coast of Greenland (Salomonsen 1950). Those individuals that nest and summer in the eastern and central Canadian Arctic, winter pelagically off the west and south coasts of Greenland and off the coasts of eastern North America (Godfrey 1966; Brown et al. 1975).

Kittiwakes return to northern Baffin Bay in mid-May. Ellis (1956) noted large flocks at the mouth of Pond Inlet on 16 May. Johnson et al. (1976a) first saw kittiwakes in Lancaster Sound on 20 May in 1976. McLaren and Renaud (1979) first recorded kittiwakes on 14 May in 1978; McLaren (1980) first noted them during a survey on 17-22 May in 1979, when an estimated 9,500 birds were offshore, primarily in the southern portions of Baffin Bay. The initial phase of spring migration is primarily on a broad offshore front, rather than north along the fast ice edge east of Baffin Island (McLaren 1980).

Kittiwakes return to their colonies in late May. In 1978, over 3,500 birds were seen at Coburg Island on 23 May (McLaren and Renaud 1979). More than 2,100 were present near the Cape Hay colony on 31 May 1976 (Johnson et al. 1976a). Tuck and Lemieux (1959) reported that the Cape Graham Moore colony on southeast Bylot Island was occupied by 30 May. Over 50 percent of the 17,000 kittiwakes estimated to be in Lancaster Sound on 30 May-1 June 1976 were offshore (Johnson et al. 1976a); these birds may have been moving west to colonies in the central arctic. By 6-7 June 1976, more than 26,000 were estimated to be in Lancaster Sound, but only 2,200 were offshore and more than 20,000 were along the northwest coast of Bylot Island.

Numbers and densities of kittiwakes in the area increase steadily through June. Although many birds migrate north offshore, substantial numbers also appear to move north along the fast ice edge off the east coast of Baffin Island in mid-June, when open water first appears regularly. By mid-June, kittiwakes are common along many of the coasts and fast ice edges bordering eastern Lancaster Sound and western Baffin Bay, and are abundant near the colonies on Coburg Island and Bylot Island (Fig. 2.7.13). There are also several areas away from the nesting colonies where large concentrations of kittiwakes frequently occur. One such area is the south coast of Devon Island. Although kittiwakes are not particularly numerous in this area prior to mid-June, large numbers begin to appear along the coast east of Cape Warrender in late June. Almost 5,000 kittiwakes were counted there on 30 June 1979 (Fig. 2.7.13). A second area of concentration is the fast ice edge along the northeast coast of Bylot Island. Over 2,200 kittiwakes were present along a 60-km stretch on 19 June 1978 and 1500 were counted in the same area on 19 June 1979 (McLaren and Renaud 1979; McLaren 1980).

Kittiwakes are also common in offshore areas prior to nesting, which begins in late June and early July. An average of about 21,000 kittiwakes were estimated to be offshore during surveys between 1 June and 8 July 1978; more than 42,000 were estimated to be in northwest Baffin Bay on 26-28 June (McLaren and Renaud 1979). In 1979, over 47,000 were in the same areas on 28 June-2 July, and 23,000 were in eastern Lancaster Sound on 9-15 July (McLaren 1980). In Baffin Bay, densities are higher in the northwest than in areas farther south (McLaren 1980). The colonies are all in the northwest. Kittiwake distribution in offshore areas probably varies with ice conditions. For example, densities in Lancaster Sound during June and early July were about twice as high in 1979 as in 1978; this was probably due to the generally ice-free waters in the eastern part of the sound in 1979; more pack ice was present there in 1978. Kittiwakes in offshore areas prefer waters with little or no pack ice (McLaren and Renaud 1979; McLaren 1980).

Black-legged kittiwakes begin egg-laying in late June and early July. The incubation period is 27 days (D.N. Nettleship, pers. comm.). During the incubation period, kittiwakes tend to remain near the nesting colonies. Consequently, concentrations of several thousand individuals regularly occur along the south side of Coburg Island, and off the northwest and southeast coasts of Bylot Island. During the first half of July 1979, more than 3,500 kittiwakes were also present along the south coast of Devon Island, although only a few hundred were present there at that time in 1976 and 1978. Elsewhere, kittiwakes are common along many of the coasts and ice edges south from Ellesmere Island to Pond Inlet. Only small numbers are present along the coast and landfast ice edge along east Baffin Island (McLaren 1980).

Densities of kittiwakes in offshore areas are generally much reduced during July, when many of the birds that were offshore during June have moved to nesting colonies. Only nine percent of an estimated 16,000 kittiwakes present in eastern Lancaster Sound on 12-13 July 1976 were offshore (Johnson *et al.* 1976a). (This 16,000 estimate excludes birds at the Cape Hay colony itself.) Although kittiwakes are generally evenly and sparsely distributed in offshore areas at this time, densities tend to be higher in waters adjacent to nesting colonies, e.g., in the southeastern portion of eastern Lancaster Sound.

Kittiwake chicks hatch in mid- to late July. The nestling period is about 38 days (D.N. Nettleship, pers. comm.), and fledging begins in the last half of August. Most young have left the nests by early September.

During the first half of August, the distribution of kittiwakes in eastern Lancaster Sound and northwest Baffin Bay is much like that during the incubation period in July: most kittiwakes are at or near their nesting colonies. At this time densities are generally much higher in the easternmost parts of Lancaster Sound, i.e. near the colony on northwest Bylot Island, than in the more westerly parts. In 1978, when few kittiwakes are believed to have nested (LGL Ltd., unpubl. data), densities near colonies were not appreciably different from those in other areas.

In late August, kittiwake numbers in eastern Lancaster Sound and northwest Baffin Bay increase. In 1978, numbers offshore in the sound increased from about 1,300 in mid-July to about 7,000-8,300 in late August (McLaren and Renaud 1979). As well, more than 2,500 were counted along the southeast coast of Ellesmere Island and almost 5,000 were along the east coast of Coburg Island on 22 August 1978. Large concentrations also occur along the northeast and south coasts of Devon Island. Numbers in coastal areas continue to increase throughout early September (Fig. 2.7.14). More than 6,000 kittiwakes were counted between Philpots Island and Cape Warrender, Devon Island, on 5-6 September 1976, and more than 4,000 were seen in coastal areas of Navy Board Inlet and Pond Inlet on 8 September 1978.

Numbers of birds at these concentrations increase throughout September, with peaks generally in the last half of September. Important localities include the southeast coast of Ellesmere Island--counts of 8,500 kittiwakes on 21 September 1978; northwest Bylot Island and north Baffin Island--10,000 birds on 13 September 1976; and southeast Bylot Island and northeast Baffin Island--7,800 on 24-25 September 1978. Even larger concentrations occur along the southeast coast of Devon Island (Johnson et al. 1976a; McLaren and Renaud 1979). In 1978, an estimated 25,000 to 40,000 kittiwakes were present there on 15 September, 34,000 were present on 21 September, and 21,000 were present on 27 September. Along southeast Devon Island, by far the greatest numbers and densities are in Bethune Inlet, between Philpots and Devon islands, although large concentrations occur west to at least Croker Bay. In 1979, almost 22,000 kittiwakes were counted in Bethune Inlet on 19 September and another 15,000 were seen on the same day between Cape Sherard and Croker Bay. More than 5,000 were still present on 29 September 1979 (McLaren and Renaud 1982). Most of these large concentrations were found along partially submerged glacier fronts, particularly in Bethune Inlet and along Ellesmere Island. At this time in 1978, kittiwake densities were significantly higher along glacier fronts than along other parts of the coastline. Apollonio (1973) and Dunbar (1973) have found high levels of nutrients in waters in front of glaciers and it is possible that these high levels are responsible for a high level of production of foods that are important to kittiwakes. Hartley and Fisher (1936) reported that, in Spitsbergen, kittiwakes concentrate at glacier fronts and feed on crustaceans.

Most sightings of kittiwakes away from coastlines are of single birds, although on 21 September 1978 a flock of over 11,000 kittiwakes was seen about three km south of Coburg Island (McLaren and Renaud 1979). Kittiwakes are also widespread in low densities throughout offshore areas during September and October. In 1976, estimated numbers in offshore eastern Lancaster Sound increased from about 2,000 birds on 5-7 September to about 13,000 on 12-13 September, which suggests that a migration of kittiwakes from central arctic colonies was underway (Johnson et al. 1976a). It is possible that these kittiwakes were part of the large concentrations present along southeast Devon Island in late September.

Kittiwakes are present in coastal areas through mid-October. Although few individuals remained north of Lancaster Sound after September, several thousand were seen regularly along the east coast of Baffin Island until at least 10 October in 1979 (LGL Ltd., unpubl. data). Their departure dates from these coastal areas likely are determined by the rate of freeze-up.

There are few data on the breeding biology of kittiwakes that nest in the high arctic. In some years, a large percentage of the breeding population may not nest (D.N. Nettleship, pers. comm.). Tuck and Lemieux (1959) found that clutch sizes of kittiwakes varied from one to three eggs in 1957 and that nests contained an average of 1.2 young by mid-August. Nettleship and Gaston (1978) found that an average of slightly less than one fledgling was produced per pair at Prince Leopold Island in 1976. Coulson (1966) found that in Great Britain female kittiwakes first nested at three to four years of age and males at four to five years of age. Coulson and Wooller (1976) determined that mean adult life expectancy of kittiwakes was five to seven years in temperate areas. There is no information on the survival rate from the time of fledging to the time of first breeding for kittiwakes from arctic colonies.

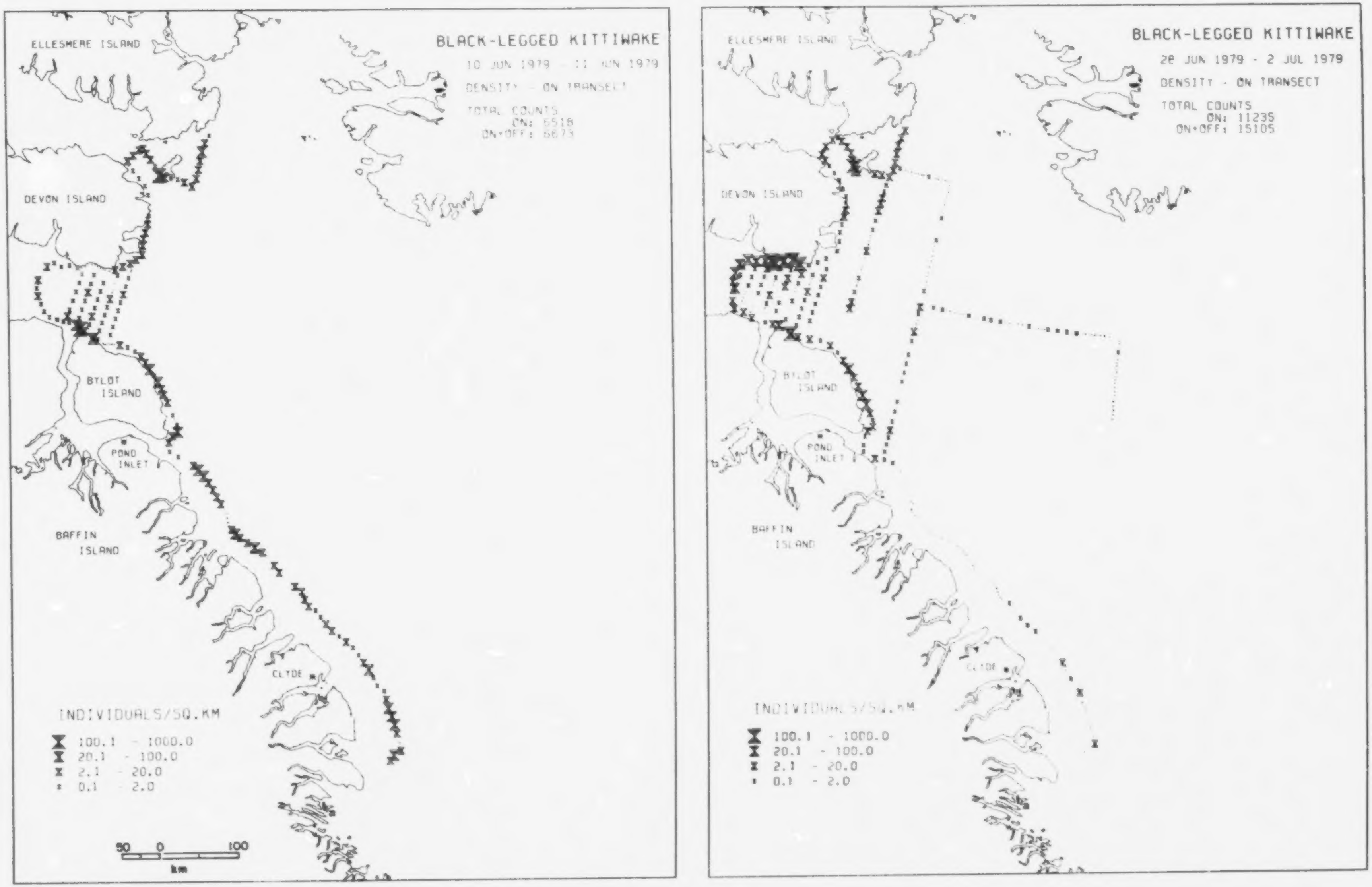

BLACK-LEGGED KITTIWAKE
10 JUN 1979 - 11 JUN 1979
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 5518
ON+OFF: 6673
ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
INDIVIDUALS/SQ.KM
100.1 - 1000.0
20.1 - 100.0
2.1 - 20.0
0.1 - 2.0
50
0
100
km
BLACK-LEGGED KITTIWAKE
28 JUN 1979 - 2 JUL 1979
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 11235
ON+OFF: 15105
ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
INDIVIDUALS/SQ.KM
100.1 - 1000.0
20.1 - 100.0
2.1 - 20.0
0.1 - 2.0

FIG. 2.7.13 Black-legged kittiwake distribution in the study area, 10-11 June 1979 and 28 June-2 July 1979. Densities shown are for four-min (~12 km) transect segments. (★) indicates sites of nesting colonies. From McLaren (1980).

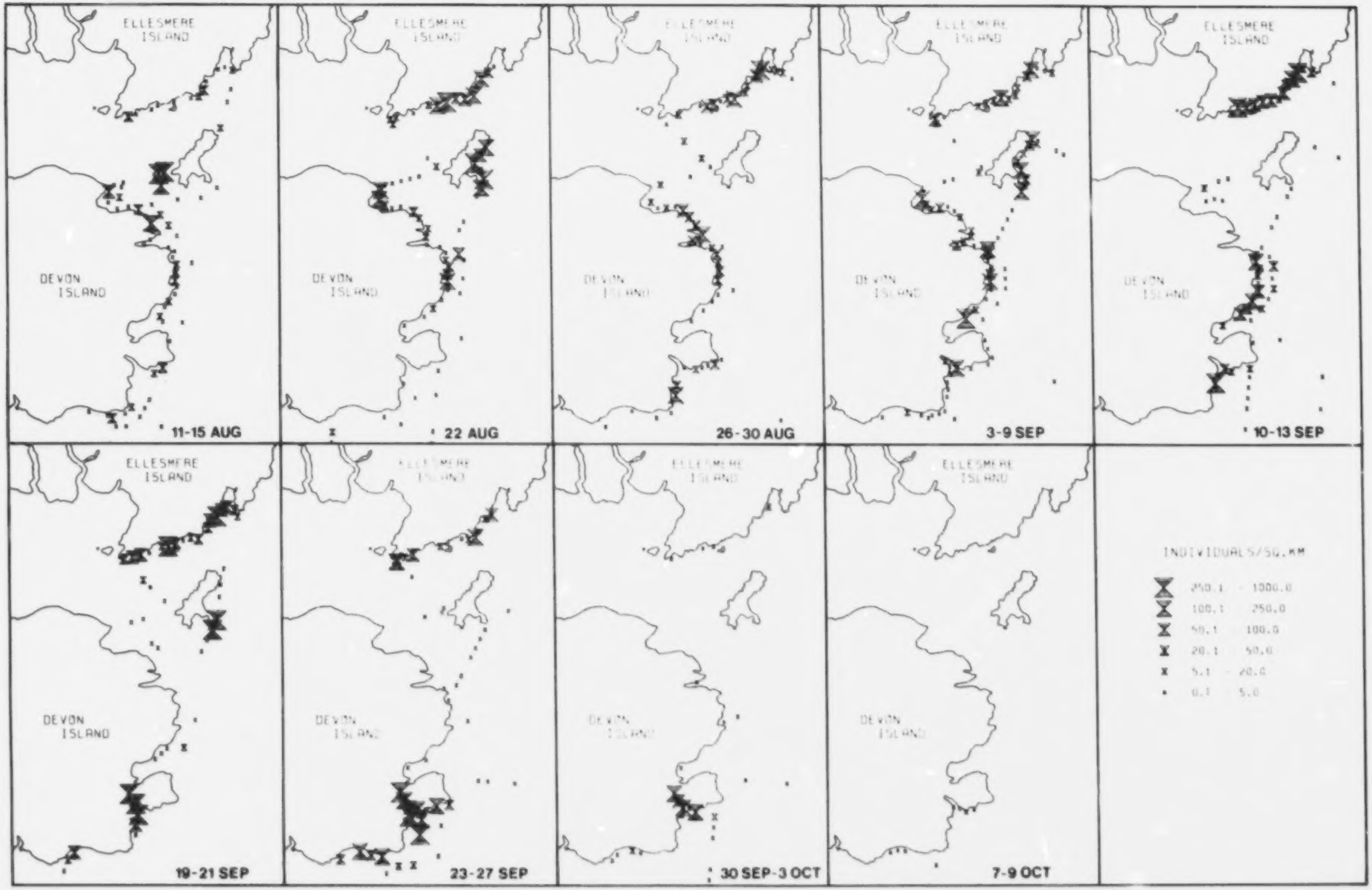

ELLESMERE ISLAND
DEVON ISLAND
11-15 AUG
22 AUG
26-30 AUG
3-9 SEP
10-13 SEP
19-21 SEP
23-27 SEP
30 SEP-3 OCT
7-9 OCT
INDIVIDUALS/SQ.KM
250.1 - 1000.0
100.1 - 250.0
50.1 - 100.0
20.1 - 50.0
5.1 - 20.0
0.1 - 5.0

FIG. 2.7.14. Black-legged kittiwake distribution along Devon and Ellesmere islands 28 July-2 October 1978. Densities shown are for two-min (~ six km) transect segments. From McLaren and Renaud (1979).

It is not known whether two- and three-year old subadult kittiwakes enter the eastern Lancaster Sound-western Baffin Bay area in the summer. Yearlings have been seen in eastern Lancaster Sound in late August (Tuck and Lemieux 1959; M.S.W. Bradstreet, pers. comm.), and Salomonsen (1967) noted that subadult kittiwakes from Greenland colonies wander north in the summer months, often moving close to their natal colonies. It is possible that some of the increases in kittiwake numbers in offshore waters in late June and July, and in coastal waters in September, are due to influxes of subadults, but this has not been confirmed.

2.7.7 Thick-billed Murre

The thick-billed murre (*Uria lomvia*) nests in colonies on coasts and islands within arctic and subarctic regions of North America and Eurasia. There are three large nesting colonies within the eastern Lancaster Sound-western Baffin Bay area; these colonies contain a total of about 320,000 pairs (Fig. 2.7.2; Gaston 1980). There are also large colonies at Prince Leopold Island (86,000 pairs) and along the northwest coast of Greenland (300,000 pairs); birds from these colonies may occur in Baffin Bay and eastern Lancaster Sound during migration.

The murres that summer in the study region are believed to winter off the southwest coast of Greenland, and possibly the northeast coast of Canada (Tuck 1961; Gaston 1980).

Thick-billed murres return from wintering areas to the eastern Lancaster Sound-western Baffin Bay area in early May, about six to eight weeks before nesting begins. They were present at Prince Leopold Island on 5 May in 1976 (Gaston and Nettleship 1981), and about 2000 were in eastern Lancaster Sound on 5 May 1978 (McLaren and Renaud 1979). Several hundred murres were at the base of the Cape Hay colony on 9 May 1979 (McLaren 1980). They have arrived at the nesting colonies in northwest Greenland by mid-May (Salomonsen 1950). Numbers in the area increase rapidly during May. In 1976, an estimated 180,000 murres were in eastern Lancaster Sound on 16-20 May, and in 1978, over 280,000 were estimated to be in eastern Lancaster Sound and northwest Baffin Bay on 23-24 May; over half a million murres were in western Baffin Bay on 24-26 May 1979, with the highest densities in the north and northwest portions (Johnson *et al*. 1976a; McLaren and Renaud 1979; McLaren 1980). During early and mid-May, most murres in the area remain in offshore waters (Fig. 2.7.15); between 4 and 18 May 1978, 92 percent of all murres estimated to be present in eastern Lancaster Sound and northwest Baffin Bay (exclusive of any on the cliffs at colonies) were offshore. By late May, however, large numbers begin to appear along coasts and ice edges and in nearshore waters. More than 9,000 were counted at the base of the colony on Coburg Island on 23 May 1978 and several thousand were also present along the fast ice edge across the entrance to Jones Sound on the same day. Over 15,000 were in front of the Cape Hay colony on 24 May 1976, and more than 8,800 were near the colony on southeast Bylot Island on 22 May 1978 (Johnson *et al*. 1976a; McLaren and Renaud 1979).

From late May until early July, murres are common and widely distributed throughout the eastern Lancaster Sound-western Baffin Bay area (Fig. 2.7.16). During this period, varying numbers of murres are present at and near the nesting colonies as prospective nesters arrive and then depart again

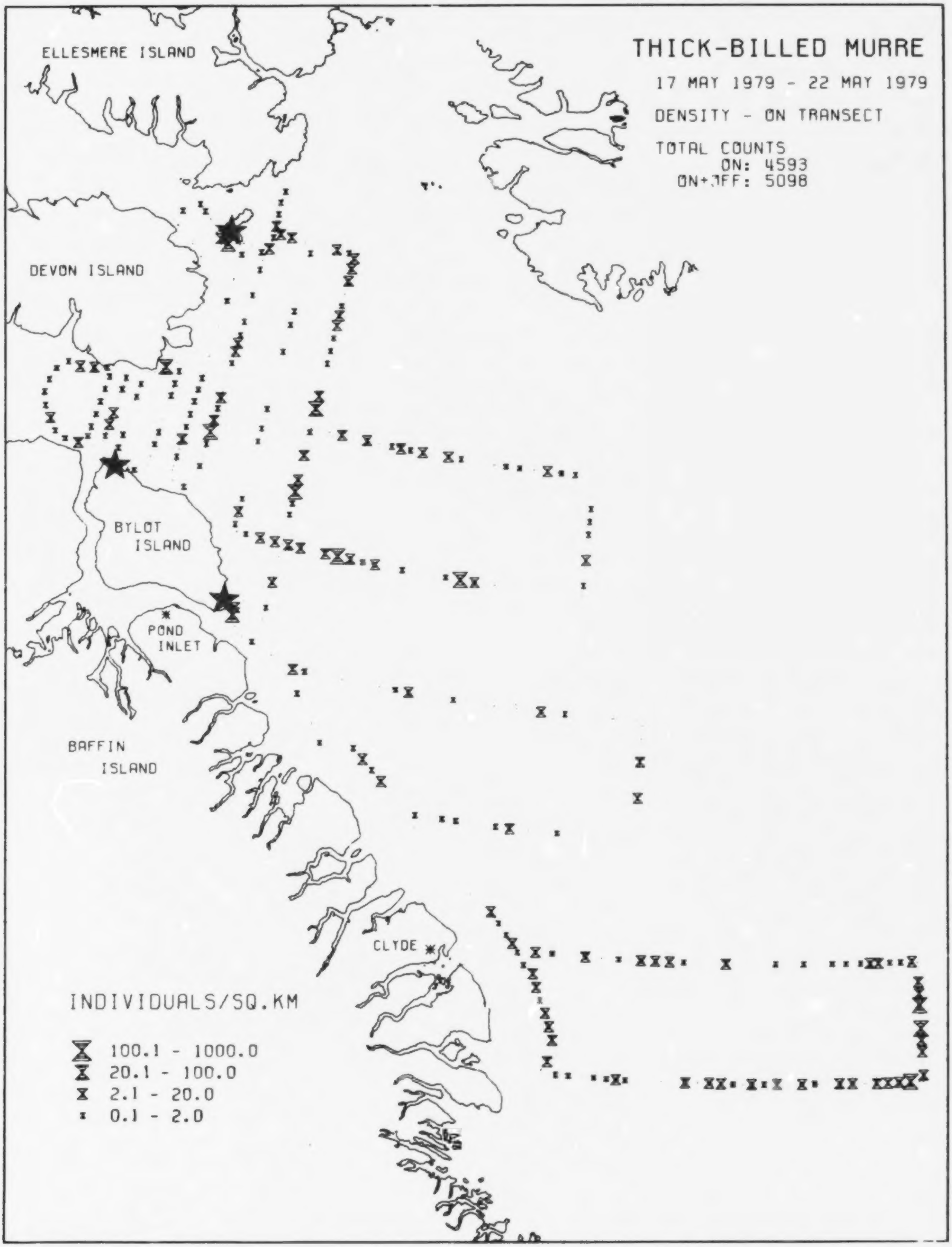

THICK-BILLED MURRE
17 MAY 1979 - 22 MAY 1979
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 4593
ON+OFF: 5098
ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
INDIVIDUALS/SQ.KM
100.1 - 1000.0
20.1 - 100.0
2.1 - 20.0
0.1 - 2.0

FIG. 2.7.15 Thick-billed murre distribution in the study area, 17-22 May 1979. Densities shown are for four-min (~12 km) transect segments. (★) indicates sites of nesting colonies. From McLaren (1980).

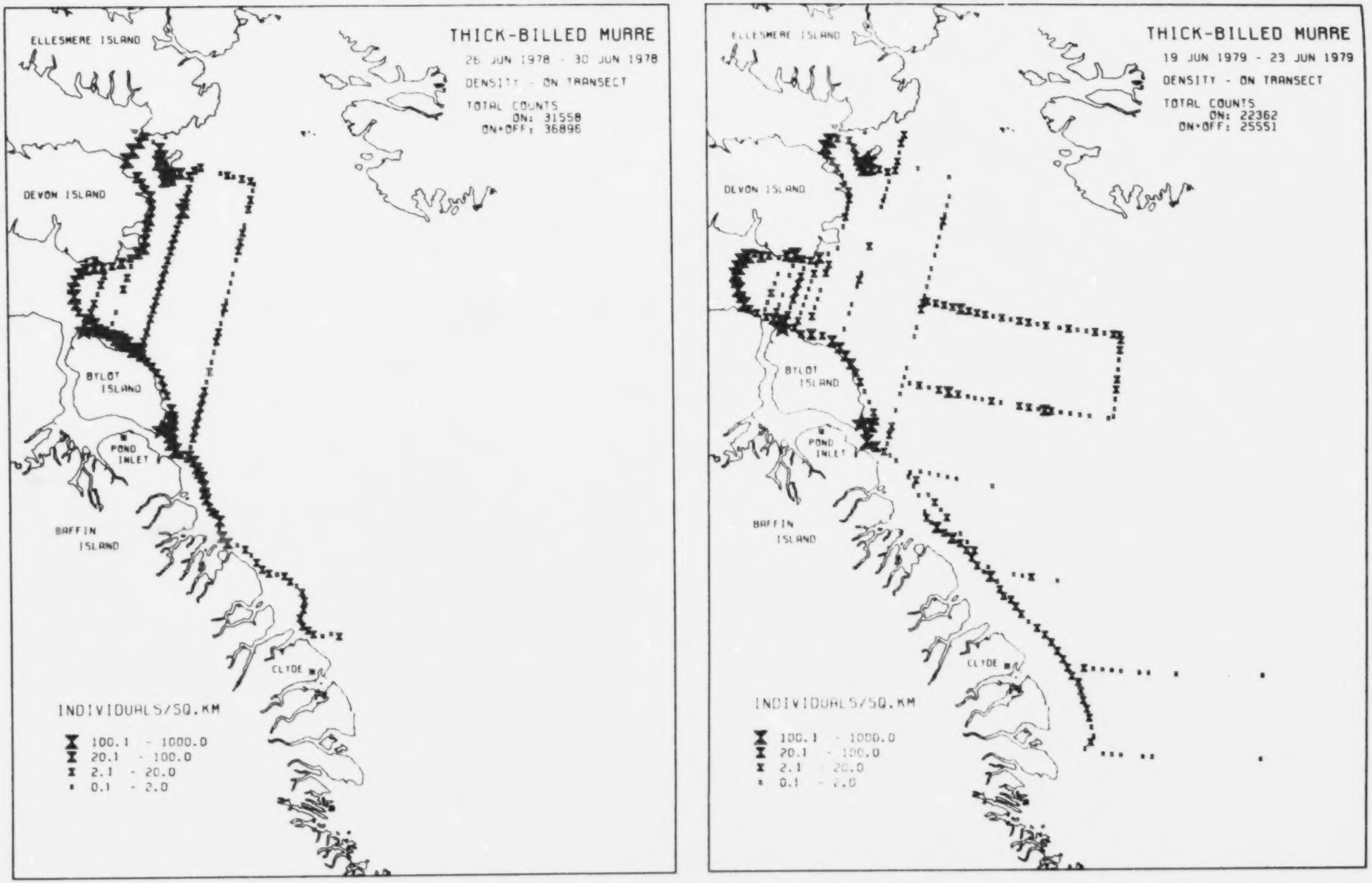

THICK-BILLED MURRE
26 JUN 1978 - 30 JUN 1978
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 31558
ON+OFF: 36896
ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
INDIVIDUALS/SQ.KM
100.1 - 1000.0
20.1 - 100.0
2.1 - 20.0
0.1 - 2.0
THICK-BILLED MURRE
19 JUN 1979 - 23 JUN 1979
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 22362
ON+OFF: 25551
ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
INDIVIDUALS/SQ.KM
100.1 - 1000.0
20.1 - 100.0
2.1 - 20.0
0.1 - 2.0

FIG. 2.7.16 Thick-billed murre distribution in the study area, 26-30 June 1978 and 19-23 June 1979. Densities shown are for four-min (~12 km) transect segments. (★) indicates sites of nesting colonies. From McLaren and Renaud (1979); McLaren (1980).

prior to nesting. However, large concentrations are also present along fast ice edges. The average density along the fast ice edge across the mouth of Jones Sound from 23 May-4 July 1978 was 364 birds/km^2, and more than 17,000 were counted there on 4 July 1978. Murres are also common along the fast ice edges to the immediate east and west of Coburg Island. They were abundant along the fast ice edge that extended across eastern Lancaster Sound and Navy Board Inlet in 1978 and 1979. They were not common, however, along the fast ice edge across the mouth of Pond Inlet, or down the east side of Baffin Island, prior to mid-June in 1978 and 1979. (This may be because this edge is often frozen over or is only a narrow lead.) However, after mid-June, they were numerous; densities along these edges decreased with increasing distance from Bylot Island. On 26 June 1978, over 5,400 murres were present along the fast ice edge across the mouth of Pond Inlet, and another 1,700 were seen along the ice edge along east Baffin Island. Large numbers persisted along the Pond Inlet floe-edge until mid-July when it began to break up; more than 3,000 were present there on 10-11 July 1978 (McLaren and Renaud 1979; McLaren 1980).

As more and more murres move to coasts and ice edges in late May and June, the proportion of murres in offshore areas decreases. By mid-June 1978 only about 65 percent of the murres estimated to be present in eastern Lancaster Sound and northwest Baffin Bay (exclusive of birds actually at the colonies) were offshore.

Densities of murres are higher in eastern Lancaster Sound and the northern parts of Baffin Bay than in areas farther south, although in extreme southeastern Baffin Bay murres are also very common in late May. Murres in southeastern Baffin Bay likely nest on the west coast of Greenland. In eastern Lancaster Sound and northwestern Baffin Bay, the distribution is highly related to the offshore ice conditions. In offshore areas, murres prefer moderate to heavy pack ice conditions (McLaren 1980).

Murre colonies at Prince Leopold Island and west of Cape Hay, Bylot Island, total about 225,000 nesting pairs (Gaston 1980). These birds would be expected to migrate through and feed in Lancaster Sound during the spring. However, in 1978 and 1979, all of Lancaster Sound west of a line from about Navy Board Inlet to Cape Warrender, Devon Island, was covered by fast ice and was thus unavailable as feeding or resting places for murres. However, the presence of fast ice had no clear or consistent effect on murre densities in offshore waters of the sound east of the fast ice edge. The average density of 6.4 murres/km^2 in offshore Lancaster Sound from 9 May to 13 July 1976, when no ice edge was present, was similar to that of 4.8 birds/km^2 recorded during the corresponding period in 1978 (McLaren and Renaud 1979) when a fast ice edge was present. In 1979, however, the average density was only 1.4 birds/km^2. Thus murre densities were more similar in 1976 and 1978, when ice conditions were ostensibly very different, than they were in 1978 and 1979, when conditions were apparently similar. A more important variable may be the amount of pack ice in offshore areas. In both 1976 and 1978, offshore Lancaster Sound frequently had a high percentage of pack ice cover during spring (Johnson et al. 1976a; McLaren and Renaud 1979); by contrast, in 1979 eastern Lancaster Sound was essentially ice free. Reduced use of these ice-free waters by murres in 1979 may have been related to their preference for offshore areas with moderate to heavy pack ice.

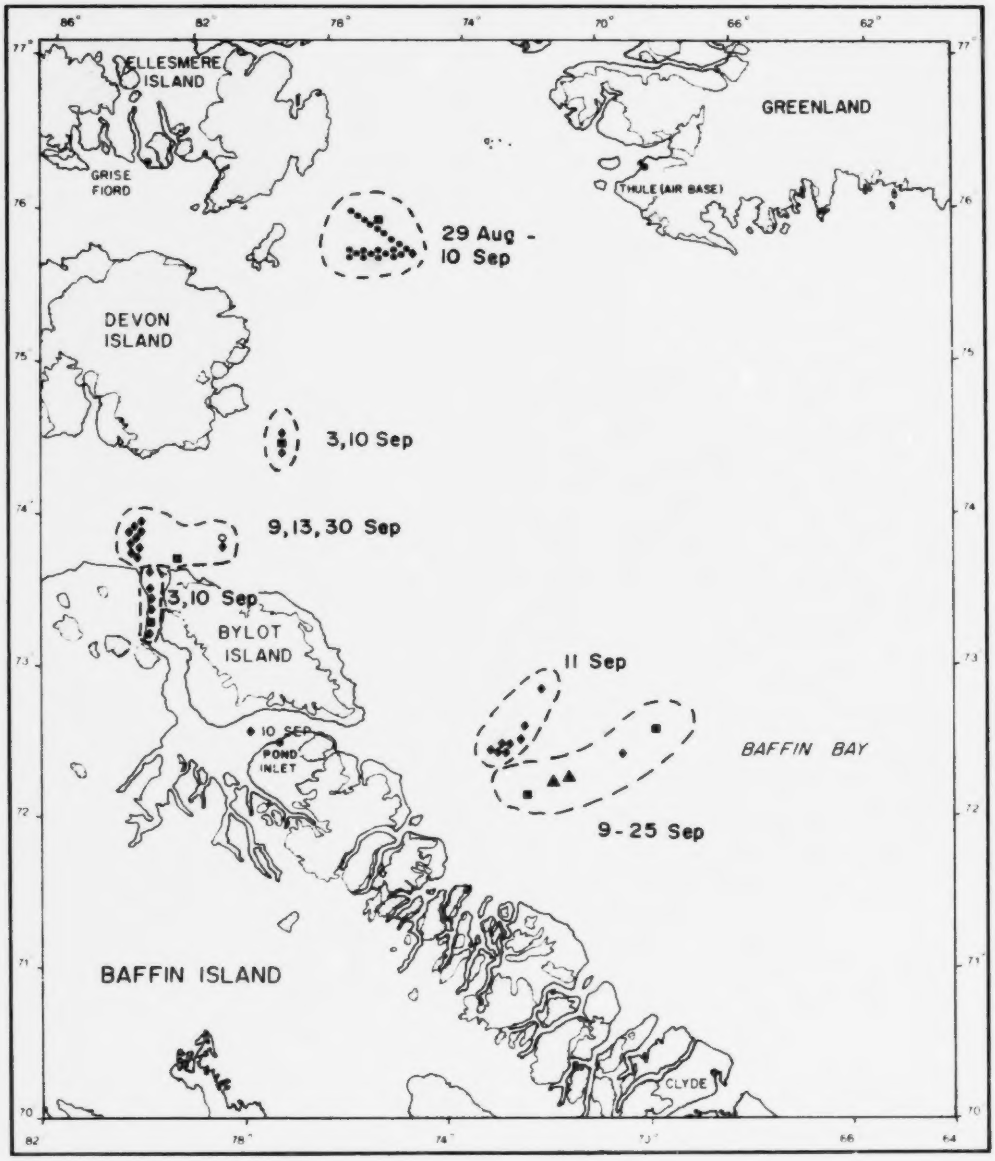

ELLESMERE ISLAND
GREENLAND
GRISE FIORD
THULE (AIR BASE)
29 Aug - 10 Sep
DEVON ISLAND
3,10 Sep
9,13,30 Sep
3,10 Sep
BYLOT ISLAND
11 Sep
10 SEP
POND INLET
BAFFIN BAY
9-25 Sep
BAFFIN ISLAND
CLYDE

FIG. 2.7.17 Distribution of thick-billed murre broods (adult/chick pairs) seen in eastern Lancaster Sound and western Baffin Bay, 1978. All sightings are of one adult and one chick. Different symbols denote different surveys. From McLaren and Renaud (1979).

Although the presence of the fast ice edge across Lancaster Sound in 1978 and 1979 did not result in higher densities in offshore areas to the east, the ice edge did influence murre distribution in the sound. In both 1978 and 1979, large concentrations of murres were found regularly in areas where, based on results from 1976, they would not normally be expected to occur, i.e. along the ice edge in the middle of Lancaster Sound. Probably, many of the murres seen along the ice edge were from the icebound colony at Prince Leopold Island, but they might also have been birds from the Cape Hay colony. Murres may fly long distances to feed along ice edges (Bradstreet 1979a, 1980b).

Thick-billed murres normally begin nesting in late June and early July. Incubation lasts for 32 days and young hatch in early August (D.N. Nettleship, pers. comm.). In 1978, however, murres began laying at colonies on northwest Bylot Island and Prince Leopold Island about three weeks later than normal (respective median dates of laying in 1978 were 18 July and 24 July; D.N. Nettleship, pers. comm.; LGL Ltd., unpubl. data).

During incubation, nesting murres tend to remain near their colonies. At this time they are abundant at the bases of their colonies on Coburg Island and Bylot Island, and common along nearby fast ice edges where they feed (Bradstreet 1980a). More than 7600 murres were counted along the ice edges to the east and west of Coburg Island on 9 July 1979, and 3000 were present along the fast ice edge across the mouth of Pond Inlet on 24 July 1978 (McLaren and Renaud 1979; McLaren 1980). Murres are also common in offshore waters away from ice edges. On 28 July 1978, a density of 17 birds/km^2 was recorded in waters up to 50 km southeast of the Coburg Island colony. This density was about eight times the average recorded in all offshore waters during July (McLaren and Renaud 1979). Murres are also more numerous in the southeasternmost part of eastern Lancaster Sound near the Cape Hay colony at this time, although present in low densities throughout all of eastern Lancaster Sound and extreme western Baffin Bay.

During August, thick-billed murres are raising their chicks. Hatching generally peaks about the beginning of August and the still-flightless chicks leave the cliffs three weeks later. Most young have fledged by the beginning of September. In 1978, however, eggs of murres that nested in and west of Lancaster Sound hatched about 20 August and most young did not begin to fledge until early September (LGL Ltd., unpubl. data; D.N. Nettleship, pers. comm.).

As during incubation in July, murres tend to remain fairly close to their colonies during chick-rearing. Thus, they are common at, and close offshore of, the nesting colonies on Coburg Island and Bylot Island. Densities tend to decrease with increasing distance from the colonies. Murres are, however, seen regularly in offshore eastern Lancaster Sound, western Baffin Bay and Jones Sound. There is some indication that birds occurring quite far from any colony are non-breeders or failed breeders (LGL Ltd., unpubl. data). Few murres are present in coastal areas away from colony sites.

Flightless murre chicks leave their natal colonies when they are 18-25 days old and undertake a swimming migration out to sea, usually accompanied by an adult male (Bradstreet 1979b). At this time adults are undergoing a remigial (wing) moult and consequently are also flightless. The first chicks left the Prince Leopold Island colony on 12 August in 1975 (Gaston and Nettleship 1981), and young were present at sea east of that colony on 17-19 August 1976 (Nettleship and Gaston 1978). Tuck (1961) observed chicks leaving Cape Hay on 15 August in 1957. In 1978, chicks were not seen at sea until late August and early September, reflecting the retarded date of nest initiation in that year (Fig. 2.7.17). On 29 August, over 20 adult/chick pairs were seen offshore 120 km northeast of Coburg Island, but it was not until 10 September that adult/chick pairs were seen northwest of Bylot Island (McLaren and Renaud 1979). The adult/chick pairs seen northwest of Coburg Island were presumably from the large colonies (300,000 pairs) in northwest Greenland, and their presence indicates that some birds from those colonies migrate down the west side of Baffin Bay. Some broods from the Cape Hay and Prince Leopold Island colonies move east and south along the north and east sides of Bylot Island; others move south through Navy Board Inlet.

Throughout late August and early September, the numbers of murres in coastal areas steadily decrease as breeders and non-breeders begin to move south. The concentrations that were seen regularly near the Bylot Island colonies in 1978 disappeared after 30 August and the flocks near the Coburg Island colony were not seen after 4 September. Much of the migration is offshore. Throughout September, murres, including flightless chicks, are present in offshore Baffin Bay. Adult/chick pairs were noted up to 160 km offshore east of Baffin Island in 1978 (McLaren and Renaud 1979). Brown (1978) reported chicks in central Baffin Bay in September. Virtually all murres have left the eastern Lancaster Sound-western Baffin Bay area by early October.

The age of first nesting of thick-billed murres has not been established; Tuck (1961) suggests the age may be three years; Birkhead and Hudson (1977) indicate the age to be four-five years in the closely related common murre (*Uria aalge*). Productivity at Prince Leopold Island has been calculated at 0.7 chicks/pair/yr, and survival of chicks from hatch to the end of the first winter is estimated at 30% (Gaston and Nettleship 1981). Birkhead and Hudson (1977) reported the survival rate of Bylot Island murres to breeding age as 34.5 percent, and the mean adult life expectancy as 11 years. Clearly, the annual recruitment of birds into the breeding population is low. Thus, the ability of murres to recover from large scale reductions of their populations would be poor.

There is evidence that thick-billed murres have suffered large reductions in their populations, primarily as a result of human influence. Shooting, gill-netting and oiling are the primary causes (Tull *et al*. 1972; Evans and Waterston 1976; Christensen and Lear 1977; King *et al*. 1979; Salomonsen 1979). The colony near Cape Hay, Bylot Island, has decreased from an estimated 400,000 pairs in 1957 (Tuck 1961) to 140,000 pairs in 1978 (Gaston 1980). The entire western Atlantic breeding population was estimated at 10 million birds in 1957 (Tuck 1961) but Gaston (1980) estimated it as 4.6 million birds in 1979.

2.7.8 Dovekie

The dovekie (*Alle alle*) does not nest on any of the islands in the eastern Canadian Arctic; there are, however, enormous nesting colonies along the northwest coast of Greenland, north of 76°N. Although there are no detailed data on the numbers that nest in this area, Freuchen and Salomonsen (1958) suggested that the population may total 30 million individuals. Dovekies from the west Greenland population winter along the edge of the polar pack ice from west Greenland to the Gulf of St. Lawrence and the northeast United States (Salomonsen 1950, 1967; AOU 1957).

In spring, the first dovekies are reported to arrive at nesting sites along northern Melville Bay, northwest Greenland, on 5 May, and at the northern parts of the breeding range on 8 May (Bruemmer 1978). Surveys conducted in 1976, 1978 and 1979 showed that a major spring migration route of dovekies passes into and through the eastern Lancaster Sound-western Baffin Bay area (Renaud et al. 1982). Migrants were first recorded on 11 May 1976, 7 May 1978 and 12 May 1979, but large numbers were not seen until mid-May. The peak of the invasion occurs about 20 May, involving many millions of birds. On 23-24 May 1976 and on 17 May 1978, an estimated 1.3 million dovekies were in eastern Lancaster Sound (Figs. 2.7.18, 2.7.19). An estimated 14 million were in Baffin Bay north of 71°30'N and west of 64°W on 14 May 1978. In 1979, estimates of numbers present on various dates were much lower: about 4.3 million birds in western Baffin Bay on 17-21 May and 1.9 million in northwest Baffin Bay on 24-26 May (Fig. 2.7.20). In 1979, unlike 1976 and 1978, only small numbers entered Lancaster Sound; the peak estimate was 33,000 dovekies on 24-26 May 1979 (Renaud et al. 1982). During the spring invasion, dovekies occur in flocks of up to 25,000 birds.

Year-to-year variation in the distribution of dovekies in eastern Lancaster Sound and Baffin Bay during May is likely a result of ice conditions. During their passage through the area in May, dovekies remain predominantly in offshore areas and they usually do not concentrate along the edges of landfast ice. In these offshore areas, peak densities of dovekies are found in areas of moderate to heavy pack ice, and the dovekies tend to avoid ice-free areas (Renaud et al. 1982). This preference was likely responsible for the virtual absence of dovekies in eastern Lancaster Sound in May 1979. Unlike previous years, when pack ice covered about 90 percent of the sound during May, eastern Lancaster Sound was virtually free of pack ice in May 1979.

Dovekies remain in large numbers in eastern Lancaster Sound and western Baffin Bay until late May. Estimated numbers in eastern Lancaster Sound in 1976 decreased from 1.3 million birds on 23-24 May to 37 birds on 30-31 May. Estimated numbers in northwest Baffin Bay in 1978 decreased from more than two million birds on 18 May to about 250,000 birds on 30 May (Johnson et al. 1976a; McLaren and Renaud 1979).

In early June, dovekie densities in the region are low. The major spring migration has passed through and most of the breeding population is presumably in the vicinity of the nesting colonies. Egg-laying occurs about mid-June (Salomonsen 1967).

In mid-and late June, numbers and densities of dovekies in Baffin Bay increase substantially. The largest numbers found were in those areas of Baffin Bay nearest to the breeding colonies on northwest Greenland (Fig. 2.7.21). More than 2 million dovekies, in densities averaging 43 birds/km^2, were estimated to be in the north-central parts of Baffin Bay on 20 June 1979 (McLaren 1980). As during May, their late June distribution is at least

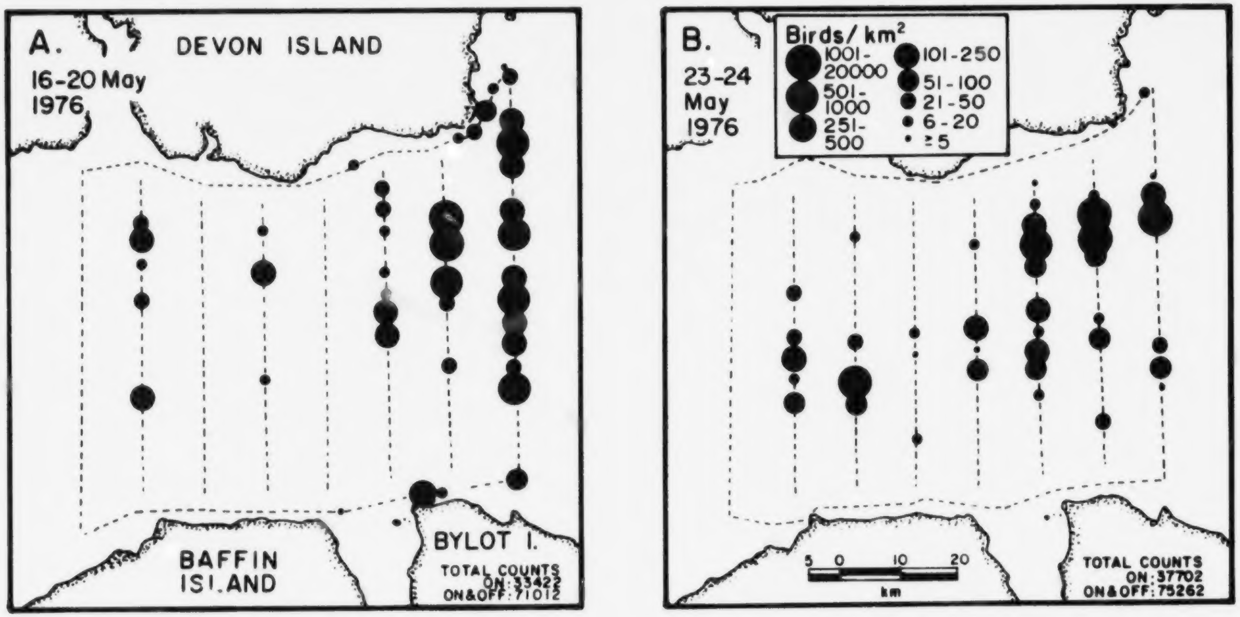

A.
16-20 May
1976
DEVON ISLAND
BAFFIN
IS!.AND
BYLOT I.
TOTAL COUNTS
ON:33422
ON&OFF:71012
B.
23-24
May
1976
Birds/ km²
1001-
20000
501-
1000
251-
500
101-250
51-100
21-50
6-20
≥5
5 0 10 20
km
TOTAL COUNTS
ON:37702
ON&OFF:75262

FIG. 2.7.18 Dovekie distribution in eastern Lancaster Sound, 16-24 May 1976. Densities shown are for two-min (~ 6-km) transect segments. From Renaud et al. (1982)

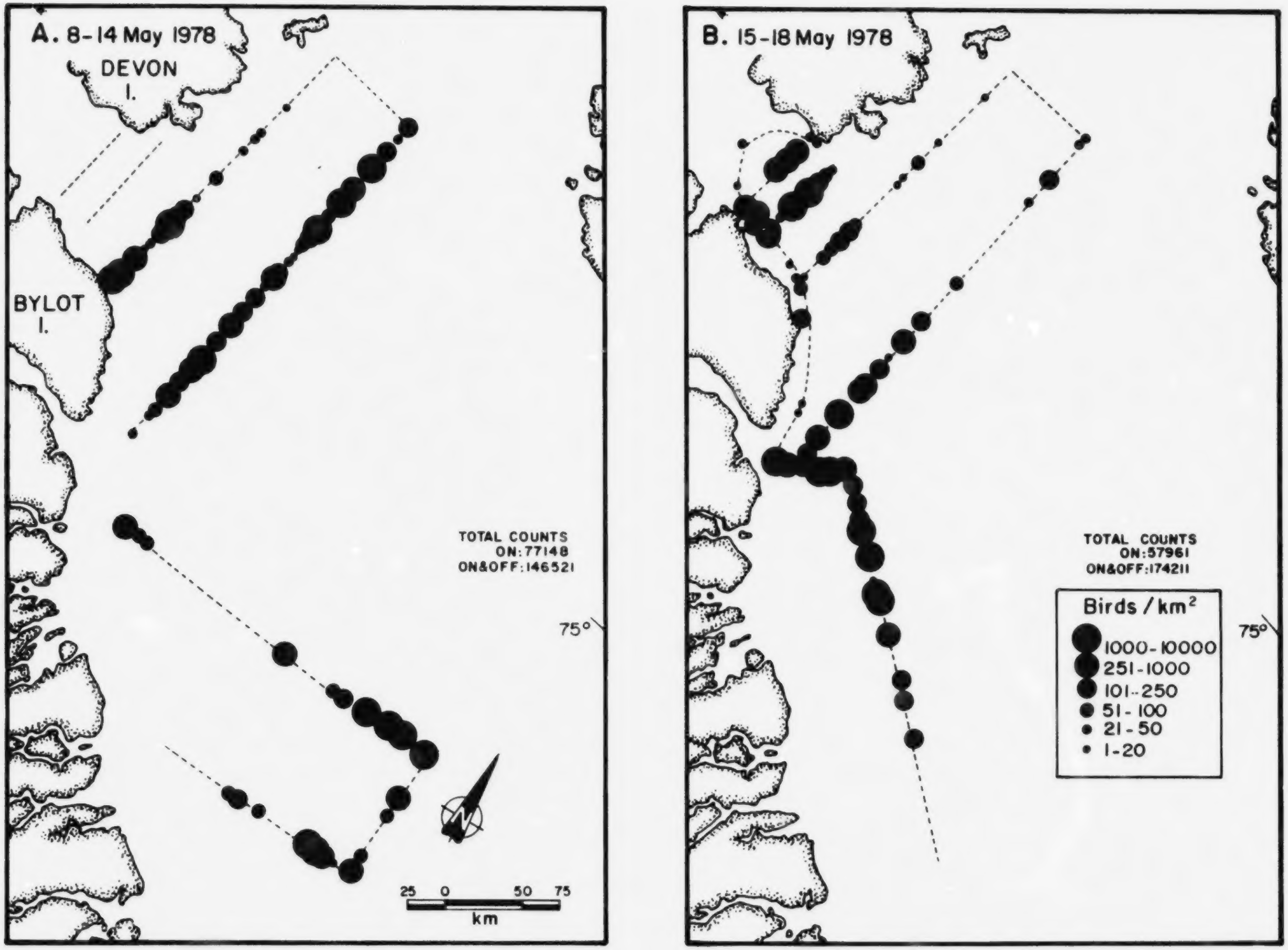

A. 8-14 May 1978
DEVON I.
BYLOT I.
TOTAL COUNTS
ON:77148
ON&OFF:146521
75°
25 0 50 75
km
B. 15-18 May 1978
TOTAL COUNTS
ON:57961
ON&OFF:174211
Birds / km²
1000-10000
251-1000
101-250
51-100
21-50
1-20
75°

FIG. 2.7.19 Dovekie distribution in eastern Lancaster Sound and western Baffin Bay, 8-18 May 1978. Densities shown are for four-min (~12 km) transect segments. (★) indicates sites of nesting colonies. From Renaud et al. (1982).

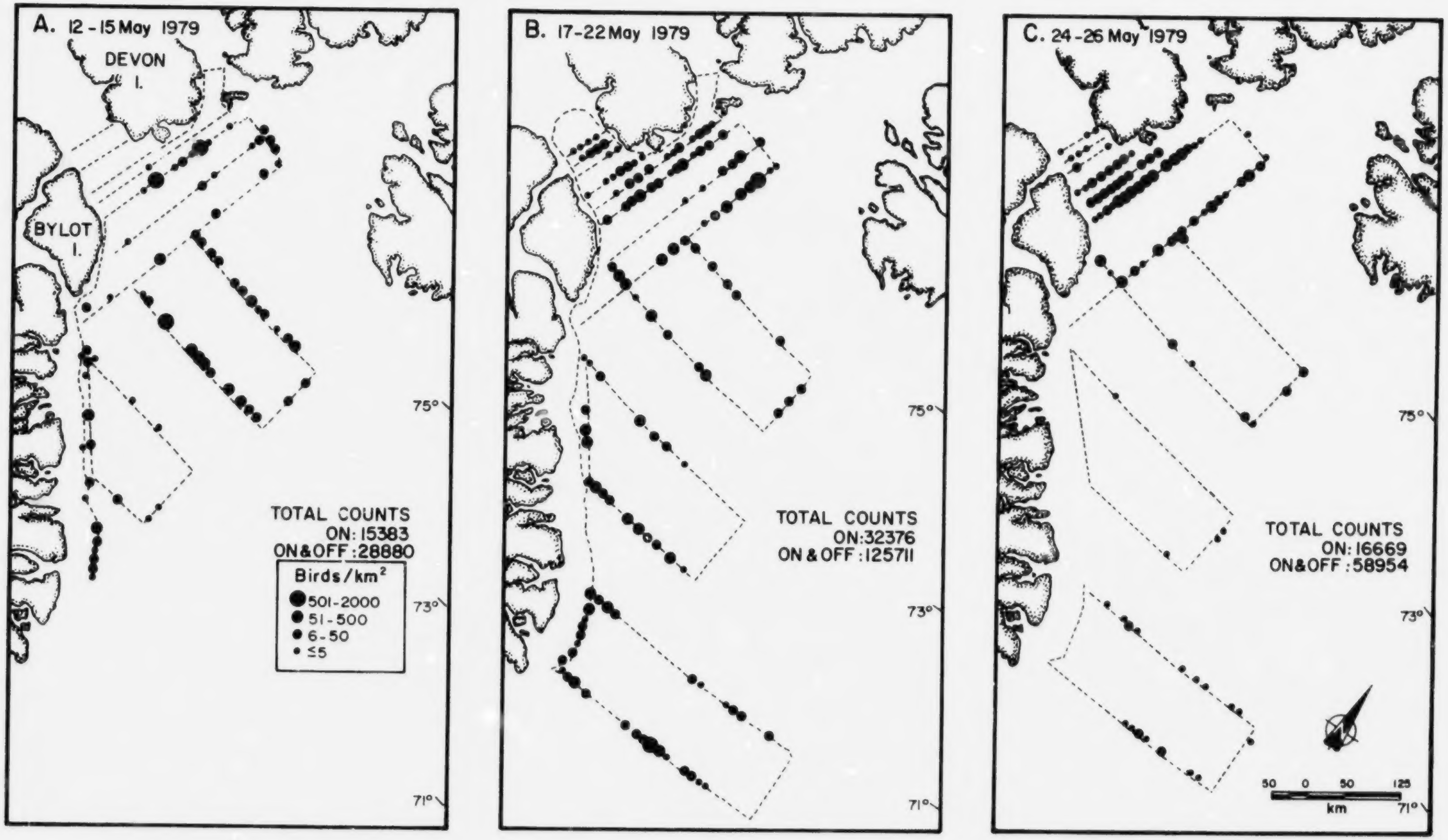

A. 12-15 May 1979
DEVON I.
BYLOT I.
75°
73°
71°
TOTAL COUNTS
ON: 15383
ON&OFF: 28880
Birds/km²
● 501-2000
● 51-500
● 6-50
• ≤5
B. 17-22 May 1979
TOTAL COUNTS
ON: 32376
ON & OFF: 125711
C. 24-26 May 1979
TOTAL COUNTS
ON: 16669
ON&OFF: 58954
50 0 50 125
km

FIG. 2.7.20 Dovekie distribution in eastern Lancaster Sound and western Baffin Bay, 12-26 May 1979. Densities shown are for four-min (~12 km) transect segments. (★) indicates sites of nesting colonies. From Renaud et al. (1982).

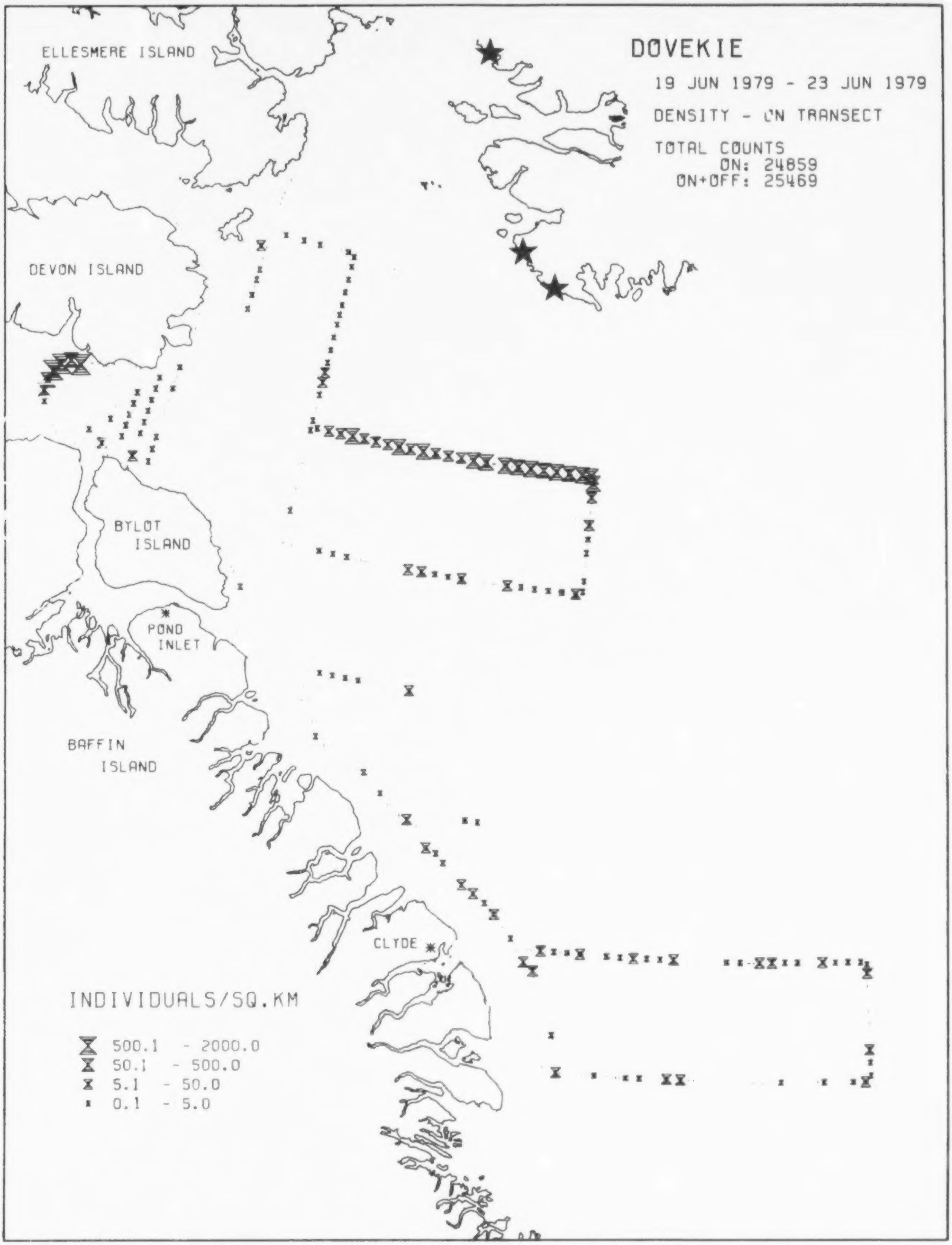

ELLESMERE ISLAND
DOVEKIE
19 JUN 1979 - 23 JUN 1979
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 24859
ON+OFF: 25469
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
INDIVIDUALS/SQ.KM
500.1 - 2000.0
50.1 - 500.0
5.1 - 50.0
0.1 - 5.0

FIG. 2.7.21 Dovekie distribution in the study area, 19-23 June 1979. Densities shown are for four-min (~12 km) transect segments. (★) indicates sites of nesting colonies. From McLaren (1980).

partly governed by ice conditions. In 1978, densities of more than 18 birds/km^2 were recorded in northwest Baffin Bay where ice-cover averaged 65 percent. In 1979, the ice cover averaged about 10 percent and the recorded density was five birds/km^2. Relatively small numbers of dovekies occur in eastern Lancaster Sound at this time, probably because of the long distance from the colonies in Greenland and the generally ice-free conditions in the sound in late June. There was, however, an unusual occurrence of 12,000 dovekies along the fast ice edge across Lancaster Sound on 19 June 1979 (Fig. 2.7.21). Dovekies are also common in southern Baffin Bay in June, although numbers and densities do not approach those in northern areas. Nevertheless, over 200,000 were estimated to be present in Baffin Bay south of 71°30'N on 22 June 1979 (McLaren 1980).

It is not known whether the birds in Baffin Bay in late June are breeding adults or subadults. In fact, all age classes may be present. Those birds present in the northeasternmost surveyed parts of Baffin Bay could have been adults that were foraging from the Greenland colonies. These colonies are about 150 km north of the survey line along which high dovekie densities were recorded. Brown (1976) indicated that dovekies may forage up to 150 km from their breeding colonies. On the other hand, the several hundred thousand dovekies in the southernmost areas of Baffin Bay in late June are more likely to be subadults spending the summer foraging in the pack ice. This area is well out of the foraging range of dovekies from colonies in northwest Greenland.

The peak of hatching at the northwest Greenland colonies is about 15-20 July and chick-rearing extends to mid-August (Roby et al. 1981). During this period, dovekies tend to remain close to their Greenland colonies. Consequently, few are seen in eastern Lancaster Sound or western Baffin Bay, and densities are low throughout these areas after July.

Southward migration commences shortly after the young fledge. Most of the birds apparently migrate across north Baffin Bay and down the west side of the bay (Salomonsen 1979); dovekies appear in the study area in late August and September. In 1978, migrating dovekies were observed northeast of Coburg Island from 21 August on, and young-of-the-year were noted east of Philpots Island on 25 August (LGL Ltd., unpubl. data). During this period dovekies are widespread in generally low densities (less than one bird/km^2 in August and September 1978) throughout much of Baffin Bay, and are rarely seen in flocks of more than a few dozen birds. By mid-September 1978, few dovekies were observed north of Bylot Island, and the exodus from northern Baffin Bay was virtually complete by the beginning of October (McLaren and Renaud 1979).

Neither the age of first breeding nor the mean life expectancy of dovekies is known. Data about nesting success are similarly sparse. Consequently, it is not possible to assess the ability of this species to recover from population reductions caused by human influences.

2.7.9 Black Guillemot

The black guillemot (Cepphus grylle) is a common and widely distributed seabird in the eastern Lancaster Sound-western Baffin Bay area. It nests in scattered pairs and colonies along rocky coastlines throughout much of the

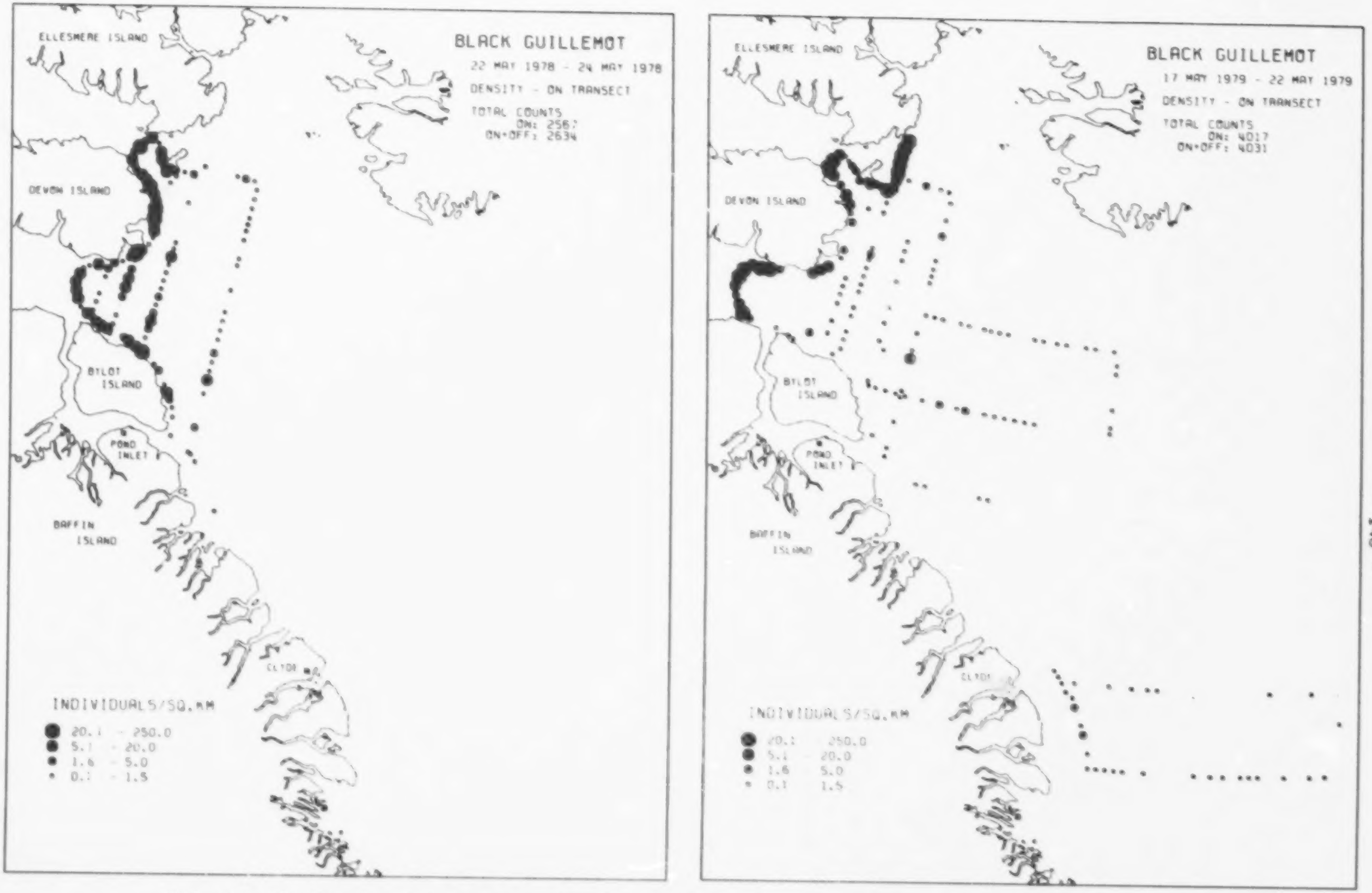

ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
BLACK GUILLEMOT
22 MAY 1978 - 24 MAY 1978
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 2567
ON+OFF: 2634
INDIVIDUALS/SQ.KM
20.1 - 250.0
5.1 - 20.0
1.6 - 5.0
0.1 - 1.5
ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
BLACK GUILLEMOT
17 MAY 1979 - 22 MAY 1979
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 4017
ON+OFF: 4031
INDIVIDUALS/SQ.KM
20.1 - 250.0
5.1 - 20.0
1.6 - 5.0
0.1 - 1.5

FIG. 2.7.22 Black guillemot distribution in the study area, 22-24 May 1978 and 17-22 May 1979. Densities shown are for four-min (~12 km) transect segments. From McLaren and Renaud (1979); McLaren (1980).

eastern arctic. There are small colonies on the northwest and southeast coasts of Bylot Island, at Cape Warrender on south Devon Island, along the northeast coast of Devon Island, and on Coburg Island (Tuck and Lemieux 1959; Johnson et al. 1976a; McLaren and Renaud 1979). There are also several large colonies to the west, bordering the waters of Jones Sound, Barrow Strait and Prince Regent Inlet (Brown et al. 1975; Alliston et al. 1976), and birds from these latter areas would be expected to pass through Baffin Bay and/or eastern Lancaster Sound during migration.

Small numbers of black guillemots apparently winter in open water portions of northern Baffin Bay. In March and April 1978, several thousand guillemots were present along ice edges along eastern Bylot, Devon and Ellesmere islands, along northwest Greenland, and in the offshore pack ice of Baffin Bay. Renaud and Bradstreet (1980) estimated the wintering population to be 5,000-10,000 birds. Most are believed to be first year birds (Salomonsen 1950); adults move at least as far south as southwest Greenland and the pack ice in Davis Strait (Salomonsen 1950; MacLaren Marex Inc. 1979c).

Guillemots are present throughout the region by early May. An estimated 7,500 birds were present in northwest Baffin Bay and easternmost Lancaster Sound on 4-7 May 1978; 90 percent of these were offshore. Numbers in the area increased through early May, but the major migration into the area occurred in the last third of the month (Fig. 2.7.22). In 1978, an estimated 45,000 were in the study area on 23-24 May, and in 1979, an estimated 39,000-51,000 guillemots were present in western Baffin Bay during two surveys from 17-26 May (McLaren and Renaud 1979; McLaren 1980). In both these years, most guillemots were widespread throughout offshore pack ice, although highest densities were recorded along coasts and fast ice edges north of Pond Inlet. Since all the large colonies in the eastern high arctic are situated west of the study area, most of the guillemots observed at this time were probablytransients. Indeed, densities in eastern Lancaster Sound and Baffin Bay do decrease somewhat in early June and remain relatively constant through the remainder of June.

Guillemots may occur along all coasts and ice edges in the area in May and June. However, they are found consistently in large numbers in certain areas, such as the fast ice edges near Coburg Island. More than 1,500 guillemots were seen along the ice edge east of Coburg Island on 21 May 1979, and average densities along this edge in May and June were more than four times higher than those along coasts and fast ice edges in the entire eastern Lancaster Sound-western Baffin Bay area. Several hundred guillemots are also present regularly along the ice edge between Coburg Island and Devon Island (McLaren and Renaud 1979; McLaren 1980).

Guillemots also occur regularly along the coast and ice edge of north and east Devon Island. Almost 1,000 individuals were counted in this area on 23 June 1978. Densities tend to be higher along the northeast coast, where a large nesting aggregation exists. A few thousand were also present along the fast ice edge across Lancaster Sound in 1979, and hundreds occurred along the northwest coast of Bylot Island at the base of the nesting colony there. Farther to the south, numbers and densities are generally unremarkable, although more than 500 guillemots were present along the ice edge off east Baffin Island, primarily opposite Buchan Gulf and south of Scott Inlet, on 21 June 1978 (McLaren and Renaud 1979).

Prior to mid-June, several tens of thousands of guillemots are in offshore waters of the study area. Thereafter, numbers offshore decrease as birds move into nesting areas. In 1978, however, over 30,000 guillemots were estimated to be offshore on 26-27 June. In that year, nesting was delayed by about three weeks and it is possible that many breeding birds had not yet moved to their colonies. Only small numbers of guillemots were present offshore in late June of 1976 and 1979. By early July, only small numbers of guillemots remain offshore.

The presence of fast ice throughout most of Lancaster Sound may have altered the normal distribution of guillemots during late spring and early summer in 1978 and 1979. Large guillemot concentrations (up to 23 birds/km^2) in the middle of Lancaster Sound in mid-June 1979, albeit along the ice edge, were atypical. Even in offshore areas away from ice edges densities were high; in 1976 offshore densities in Lancaster Sound from 4 May to 13 July averaged 0.15 birds/km^2 (LGL Ltd., unpubl. data), whereas during the same period in 1979 there were 0.43 birds/km^2, or about three times as many. In 1979 (and 1978) the large numbers of guillemots that nested in the central arctic may have been forced to remain in eastern Lancaster Sound (and Baffin Bay) until the fast ice in the sound broke up.

In May and June, guillemot densities along fast ice edges and along ice-free coasts are similar, and in both habitats densities decrease with increasing pan ice cover. In offshore areas, however, guillemots prefer areas with substantial pack ice to areas with little or no pack ice.

Black guillemots nest in late June and the first half of July. Incubation lasts for 28 days and young first appear in late July. In 1978, however, nesting at Prince Leopold Island (and presumably other central arctic colonies) was delayed by about three weeks (D.N. Nettleship, pers. comm.).

During incubation, black guillemots tend to remain within a few km of their nesting areas. Only small numbers are offshore. In summer, concentrations of guillemots occur consistently at the southeast and southwest headlands of Coburg Island, and along the northeast coast of Devon Island and the northwest coast of Bylot Island, all sites of nesting colonies. In 1978, hundreds of guillemots were also recorded along the fast ice edges northeast of Coburg Island and across Lancaster Sound, prior to the disintegration of the fast ice in late July. The birds along these edges were presumably foraging birds from colonies on Coburg Island and in the central arctic, respectively.

Several hundred guillemots also occur regularly along the fast ice edge off the east coast of Baffin Island during summer. These are probably foraging birds from nesting areas along the rugged east coast of Baffin Island. However, the specific locations of those nesting areas have not been identified.

Young black guillemots begin to hatch in late July. They remain in the nest for about three weeks, after which they can fly. Most have fledged by the end of August. In 1978, fledging in the central arctic was presumably about two to three weeks later than normal. At Cape Hay, most adults had

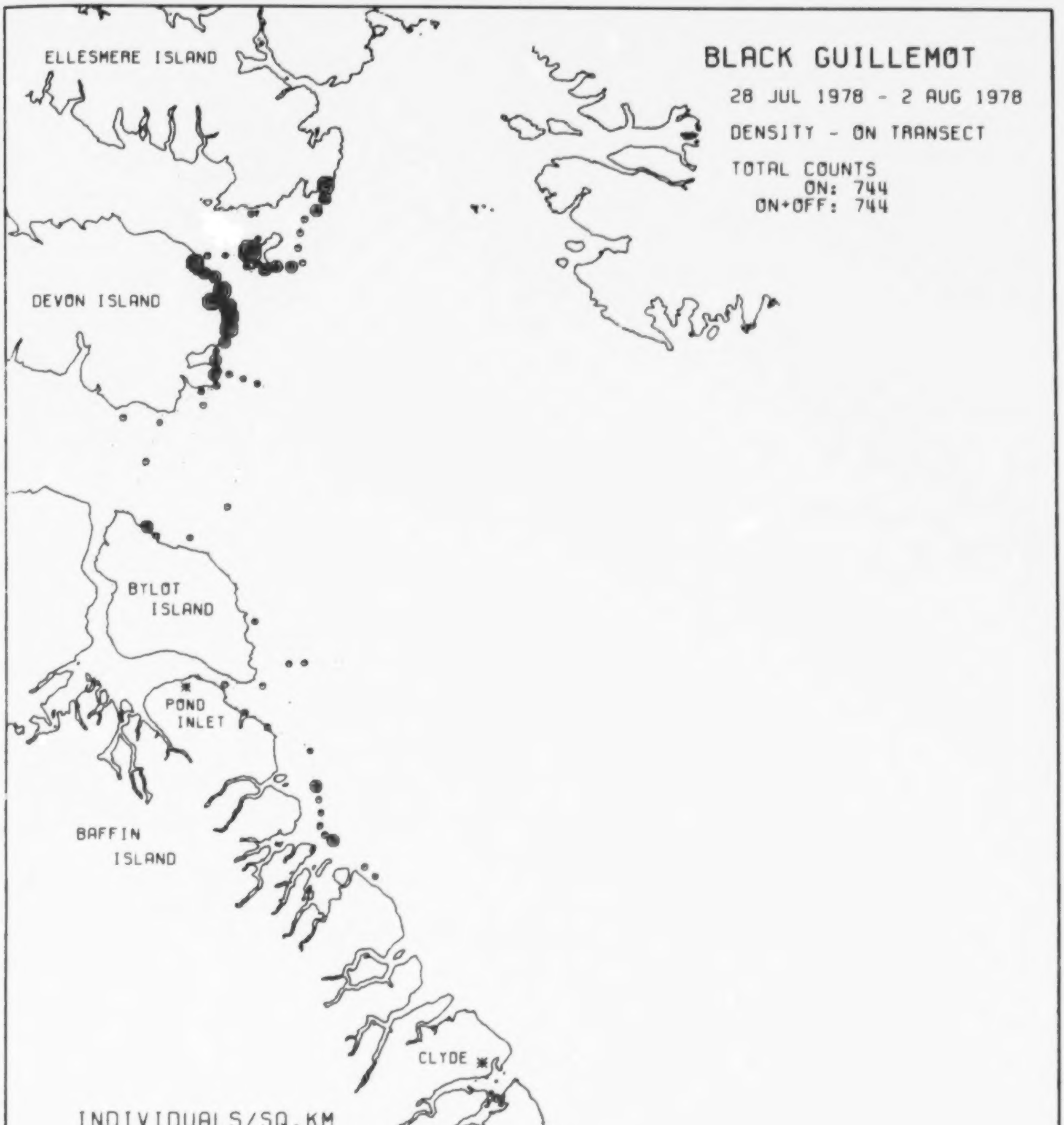

ELLESMERE ISLAND
BLACK GUILLEMOT
28 JUL 1978 - 2 AUG 1978
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 744
ON+OFF: 744
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
INDIVIDUALS/SQ.KM
20.1 - 250.0
5.1 - 20.0
1.6 - 5.0
0.1 - 1.5

FIG. 2.7.23 Black guillemot distribution in the study area, 28 July-2 August 1978. Densities shown are for four-min (~12 km) transect segments. From McLaren and Renaud (1979).

abandoned the cliffs by the second week of September, although an adult was seen feeding a chick on 10 September. There are no data on nesting success in that 'late' season.

Black guillemots tend to remain fairly close to their nest sites during chick-rearing. Consequently, the distribution of guillemots in late July and the first half of August is similar to that during the incubation period in early and mid-July: concentrations of guillemots occur around Coburg Island, northeast Devon Island and northwest Bylot Island (Fig. 2.7.23). Densities of guillemots near the colonies decrease gradually through August, and then decrease more abruptly in late August and early September as young and adults leave the colonies.

During September, guillemots are widely distributed in low densities throughout much of the coastal and offshore area of eastern Lancaster Sound and western Baffin Bay. In 1976, an increase in numbers of guillemots in eastern Lancaster Sound was detected in late September (Johnson et al. 1976a), perhaps reflecting a passage through the sound from nesting areas farther to the west. No such movement was detected during surveys in 1978, possibly reflecting poor nesting success in the central arctic colonies due to the late season. Guillemots probably remain in the area through October, and move south only when forced to by freeze-up. They were still common along the east coast of Baffin Island in mid-October 1979 (LGL Ltd., unpubl. data).

2.7.10 Other Species

Yellow-billed loon (Gavia adamsii)--The yellow-billed loon nests throughout the central and western arctic tundra and winters in Pacific waters (Godfrey 1966). It is a casual visitor to eastern Lancaster Sound and western Baffin Bay; only eight individuals were recorded during almost 40,000 km of aerial surveys along coasts and ice edges in 1976, 1978 and 1979 (Johnson et al. 1976a; McLaren and Renaud 1979; McLaren 1980). All sightings were made between 15 June and 6 July and were probably of non-breeding wandering birds.

Arctic loon (Gavia arctica)--In North America the arctic loon winters in Pacific waters and nests most commonly on low arctic tundra (Palmer 1962). Although nesting has been documented in the Pond Inlet area (Renaud et al. 1981) this species is rare in the eastern Lancaster Sound-western Baffin Bay area. Only four individuals were identified during surveys in 1976, 1978 and 1979 (Johnson et al. 1976a; McLaren and Renaud 1979; McLaren 1980). Most individuals that have been reported are probably non-nesting wanderers.

Red-throated loon (Gavia stellata)--The red-throated loon nests on small ponds in suitable lowland habitat on all of the major islands in and surrounding the eastern Lancaster Sound-western Baffin Bay area (Godfrey 1966). There is no estimate of the number of pairs that nest in the region. Red-throated loons are seen almost exclusively along coasts and fast ice edges, and only rarely, if at all, in offshore waters (McLaren and Renaud 1979; McLaren 1980).

Red-throated loons migrate into the area in mid- to late June. An important migration route follows the edge of the fast ice off the east coast of Baffin Island (McLaren 1980). From then until mid-September, when most have migrated south, they are widely distributed along the coasts of Baffin, Bylot and east Devon islands. An important summering area is along the southwest coast of Bylot Island (McLaren and Renaud 1979).

Cormorants (Phalacrocorax spp.)--Neither the great cormorant (P. carbo) nor the double-crested cormorant (P. auritus) is expected to occur in high arctic areas, although the former nests along the coast of southwest Greenland (Salomonsen 1950) and the latter has been identified on southern Baffin Island (Palmer 1962). However, single individuals (not identified to species), were seen near Devon and Coburg islands in June 1978 (McLaren and Renaud 1979).

Canada goose (Branta canadensis)--The Canada goose is widely distributed throughout the low and central arctic tundra in North America. It is, however, rare and irregular in the eastern Lancaster Sound-western Baffin Bay area. Four individuals were seen in the coastal waters of Lancaster Sound in 1976 and 1979, all between 31 May and 10 June (Johnson et al. 1976a; McLaren 1980).

Brant (B. bernicla)--The brant is a marine-associated goose that nests in Siberia, Alaska, Greenland, Spitzbergen and Canada. It is not a common summer resident in the eastern Lancaster Sound-western Baffin Bay area. About 500 were seen during aerial surveys in 1978 and 1979; all were seen between 8 June and 9 September, and more than 90 percent were seen between 8 and 23 June. Virtually all were along coasts and fast ice edges (McLaren and Renaud 1979; McLaren 1980). Johnson et al. (1976a) noted a flock of moulting brant along south Devon Island on 5 July 1976. The relatively small numbers seen, the timing of sightings, and the fact that most of those seen were in flocks indicates that this species use the waters in the area primarily for staging or resting while en route to (or from) nesting areas farther to the north or west. One population nesting on islands west of the study area winters in Europe (Maltby-Prevett et al. 1975); many or all of those brant may migrate through the area.

Snow goose (Chen caerulescens)--The snow goose nests locally across the arctic and subarctic from northeast Siberia to northwest Greenland (Godfrey 1966). One subspecies, the greater snow goose, nests in colonies and scattered pairs in the central and eastern high arctic, including several islands in the eastern Lancaster Sound-western Baffin Bay area. The largest nesting aggregation of this subspecies, estimated to include 20,000 breeding birds, occurs on southwest Bylot Island (H. Boyd, in C.W.S. 1972). Other nesting areas include coastal lowlands on Philpots Island, south Devon Island and northeast Bylot Island and along the south shores of Eclipse Sound and Milne Inlet (Johnson et al. 1976a; McLaren and Renaud 1979).

Most greater snow geese nest within a few km of seacoasts (Lemieux 1959). However, few actually use coastal waters prior to brood-rearing. Snow geese migrate into the region in early June. They apparently go straight to nesting areas and do not use coastal waters for staging or resting (McLaren and Renaud 1979; McLaren 1980). Over 90 percent of more than 6,000 snow geese seen during surveys in 1978 were along southwest Bylot Island and almost 98 percent were seen during August when geese were rearing their broods. During the first half of August most geese were seen on or over the lowlands of southwest Bylot Island. During the last half of the were of broods and adults in the coastal waters of Eclipse Sound and Navy Board Inlet. In early September 1978, small flocks of migrating snow geese, including young-of-the-year, were seen flying south along the east coast of Baffin Island. They were last seen in the region on 12 September (McLaren and Renaud 1979).

Red phalarope (Phalaropus fulicarius)--The red phalarope is a shorebird with a circumpolar nesting distribution. During nesting it is a terrestrial species. In late summer the young may congregate along coasts. For the rest of the year this species is largely pelagic in distribution. Although its nesting distribution has not been documented completely in the eastern Lancaster Sound-western Baffin Bay area, it probably nests wherever there is tundra with ponds and shallow lakes (Godfrey 1966). Known nesting areas include Ellesmere Island (Godfrey 1966), northern Devon Island (Hussell and Holroyd 1974; Pattie 1977) and near Pond Inlet (Renaud et al. 1981). Tuck and Lemieux (1959) saw many young-of-the-year along the southwest coast of Bylot Island.

The major spring influx of red phalaropes into the area is in mid-June. During this migration, many, if not most, are present in offshore areas. In late August 1978, they were commonly seen along the southwest coast of Bylot Island. They were last seen in 1978 during a survey on 18 September (McLaren and Renaud 1979).

Jaegers (Stercorarius spp.)--All three species of jaegers nest in the Canadian arctic. The pomarine jaeger (S. pomarinus) is reported to breed on southeast Devon Island and southwest Bylot Island (Tuck and Lemieux 1959; Godfrey 1966). Parasitic (S. parasiticus) and long-tailed (S. longicaudus) jaegers both nest in suitable habitat throughout the area (Godfrey 1966).

During surveys in 1978 and 1979, jaegers were widely, but uncommonly, distributed throughout the eastern Lancaster Sound-western Baffin Bay area. They were seen primarily along coasts and landfast ice edges of Devon, Bylot and Baffin islands, and in offshore waters up to 50 km from a coastline. All three species first appeared in the area during the second week of June. In 1978, pomarine, parasitic and long-tailed jaegers were last seen on 28 August, 9 and 10 September, respectively. The small number seen (450 in 1978 and 1979) indicates that none of the three species is particularly common anywhere in the area. A spring migration route follows the fast ice edge off east Baffin Island (McLaren and Renaud 1979; McLaren 1980).

Great black-backed gull (Larus marinus)--The great black-backed gull nests along the east coast of Canada and the northwestern U.S.A. north to Labrador (Godfrey 1966), and along the west coast of Greenland north to Disko Bay (Brown et al. 1975). Non-breeding wanderers may be found along southern Baffin Island.

In 1978 and 1979, 15 individuals were seen in the eastern Lancaster Sound-western Baffin Bay area from 8 May to 26 September (McLaren and Renaud 1979; McLaren 1980). These few records indicate that this species is a rare visitor to the area. The birds were probably non-breeding individuals that had wandered north of their nesting range.

Thayer's gull (L. thayeri)--The Thayer's gull is a summer resident in arctic Canada and northwest Greenland and winters on the Pacific coast (Godfrey 1966). Within the eastern Lancaster Sound-western Baffin Bay area, nesting has been reported on northwest Bylot Island (Tuck and Lemieux 1959) and on south Devon Island (Duvall and Handley 1946; Johnson et al. 1976a), and several colonies have been found in the fiords along the south coast of Ellesmere Island (C.W.S. 1972; McLaren 1980).

During surveys in 1978 and 1979, Thayer's gulls were first seen on 12 May. However, the major influx does not occur until mid-June. During spring migration, Thayer's gulls are present both along coasts and fast ice edges, and in offshore areas. After migration, this species is seen almost exclusively along coasts and ice edges from central Baffin Island north to southeast Ellesmere Island. Thayer's gulls are present in the area until at least early October (McLaren and Renaud 1979; McLaren 1980).

Sabine's gull (Xema sabini)--The Sabine's gull has a discontinuously circumpolar breeding distribution and winters in tropical waters. Its status in the eastern Lancaster Sound-western Baffin Bay area is poorly known. It is rare in the area; only 19 individuals were seen during surveys in 1976, 1978 and 1979, from 20 June to 18 September (Johnson et al. 1976a; McLaren and Renaud 1979; McLaren 1980). The species is reported to have nested on Bylot Island (Tuck and Lemieux 1959) and on east central Ellesmere Island (Snyder 1957). The sightings of Sabine's gulls along the fast ice edge off east Baffin Island in mid- to late June suggest that this species may use the ice edge as a migration route in spring.

Arctic tern (Sterna paradisaea)--The arctic tern nests in scattered pairs or colonies of up to several thousand pairs on beaches and islands throughout the eastern Arctic and west Greenland. On the west central coast of Greenland, single colonies may include up to 100,000 pairs (Salomonsen 1950); however, in the eastern Lancaster Sound-western Baffin Bay area, numbers are considerably smaller. Known nesting locations include southwest Bylot Island, east Bylot Island, southeast Devon Island and the east coast of Philpots Island (Duvall and Handley 1948; Tuck and Lemieux 1959; McLaren and Renaud 1979; McLaren 1980).

Arctic terns return from southern hemisphere wintering areas in mid-June. Most terns migrate offshore. On 19-23 June 1979, an estimated 4,700 arctic terns were in offshore areas, primarily in eastern Lancaster Sound and the adjacent waters of northwestern Baffin Bay, whereas fewer than 30 birds were counted along the coasts and ice edges between Ellesmere Island and central Baffin Island (McLaren 1980). Lancaster Sound is a migration route for terns moving west to central arctic summering areas.

In early July, arctic terns move to coastal areas to begin nesting. However, they are not widely dispersed but rather concentrate near colony sites. Away from these sites, only small numbers are present.

Arctic terns lay their eggs in July, with a peak of clutch initiation in the middle of the month. The incubation and nestling period lasts about six weeks. Most young cannot fly before late August or early September (Parmelee et al. 1967).

Southward migration begins shortly after the young-of-the-year can fly. There is little information on fall migration routes; however, much of the migration is probably offshore. Arctic terns occur in the middle of Baffin Bay during September (Brown et al. 1975; McLaren and Renaud 1979). Migration out of eastern Lancaster Sound and northern Baffin Bay is finished by mid- to late September.

2.8 Marine Mammals

This section reviews the distribution and movements of marine mammals in the eastern Lancaster Sound-western Baffin Bay area. The following accounts are based primarily on results of aerial surveys conducted in that area in 1978 and 1979. In general, surveys were flown along predetermined transects at one- to two-week intervals. Surveys were conducted from 4 May to 10 October 1978, from 9 May to 22 July 1979, and from 11 September to 17 October 1979. Surveys included flights along edges of landfast ice and ice-free coastlines in the region, and over sample areas of pack ice and open water seaward of the coasts and ice edges. Some areas of landfast ice were also sampled in spring. Details of the methodology and areas surveyed are presented in Koski and Davis (1979), Koski (1980a,b) and Koski and Davis (1980). The results of these surveys have been supplemented with those of surveys conducted in eastern Lancaster Sound in May-September 1976 (Johnson et al. 1976b; RRCS 1977). Survey routes are shown in Figure 2.7.1.

Studies of polar bears in eastern Lancaster Sound were conducted by the Northwest Territories Wildlife Service in 1978. The results of these studies were reported in Schweinsburg et al. (1980), and have been published in Schweinsburg et al. (1982).

Ten species of marine mammals were recorded during surveys in 1978 and 1979. Their distributions, abundances and habitat preferences are discussed below.

2.8.1 White Whale

The white whale or beluga (Delphinapterus leucas) is a small, toothed whale with a discontinuous circumpolar distribution. Sergeant and Brodie (1975) estimated that about 30,000 white whales inhabit Canadian waters; the population in Lancaster Sound and western Baffin Bay, the 'eastern arctic' population, has been estimated to consist of 10,000-14,000 animals (Davis and Finley 1979). This population summers in the central Canadian high arctic and the Thule District of northwest Greenland. A few hundred of these animals winter in open water areas along southeast Devon Island and in eastern Jones and Smith sounds (Finley and Renaud 1980). However, most of the 'eastern arctic' population is believed to winter off the west coast of Greenland south from Disko Bay (Kapel 1977). McLaren and Davis (1981) found white whales wintering in this area to be restricted to areas of loose pack ice within 80 km of the coastline.

Migration of white whales from Greenland wintering areas to summering areas in the central Canadian arctic begins in April and follows the ice edge up the west side of Greenland. An unknown number summer in the Thule District of Greenland; harvest statistics in this area are highest in the months of July and August (Kapel 1977). However, most animals continue across northern Baffin Bay north of 76°N, probably following leads between the landfast ice and the pack ice. Few individuals were seen in offshore areas of Baffin Bay south of 76°N during aerial surveys in the spring of 1978 and 1979, and there is no evidence of migration along the ice edge bordering eastern Baffin Island (Koski and Davis 1979; Koski 1980a). After reaching the western side of Baffin Bay, white whales proceed southward along the landfast ice edges and coasts of eastern Ellesmere and Devon islands.

Small numbers of white whales are present in northwest Baffin Bay and eastern Lancaster Sound by late April or early May (Johnson et al. 1976b; RRCS 1977; Koski and Davis 1979). Over 400 animals were seen during a survey on 4-7 May 1978, primarily along the fast ice edge across the mouth of Jones Sound and along east Devon Island (Koski and Davis 1979); these animals were presumably individuals that winter in northern Baffin Bay. Over 200 were counted in eastern Lancaster Sound, mostly along the south coast of Devon Island on 9 May 1979 (Koski 1980a). On 31 May-1 June 1978 350 white whales were seen in northern Baffin Bay and Smith Sound; most were migrating south along the east coast of Ellesmere Island (Koski and Davis 1979). A few animals were also seen offshore, migrating west towards the Ellesmere Island coast.

Numbers of white whales in the area increase through May and June. On 22-24 May 1978, over 2,200 white whales were counted along coasts and fast ice edges from Coburg Island south to north Bylot Island (Fig 2.8.1), and a similar distribution was noted during a survey on 17-22 May 1979 (Koski 1980a). This distribution, involving 2,000-4,000 animals, was noted regularly during aerial surveys in May and June, 1978 and 1979.

The peak of migration of white whales into Lancaster Sound occurs in late June and July, when several thousand animals may be present. However, movements and distribution during this migration are strongly influenced by ice conditions. In 1976, the main movement of white whales through eastern Lancaster Sound occurred from mid-June until mid-July (Johnson et al. 1976b); only a few hundred animals were recorded during each survey. In 1978 and 1979, however, fast ice covered all but the eastern end of Lancaster Sound until July, resulting in the accumulation of large numbers of white whales there. Over 2,000 white whales were counted and an estimated 4,000 were present during a survey on 30 June-1 July 1979. At such times, there is a great deal of back-and-forth movement along the south side of Devon Island, the edge of the fast ice, and the north side of Bylot Island. Some animals may be deflected as far south as the ice edge off northeast Baffin Island; over 100 individuals were seen between the mouth of Pond Inlet and Cape Adair during surveys on 21 and 30 June 1978 (e.g., Fig. 2.8.2). Most, however, are in Lancaster Sound. Large concentrations may occur at this time. For example, 1,800 individuals were present along a 60-km portion of the fast ice edge on 11 July 1978.

In years when Lancaster Sound is not covered with fast ice, most migration within the sound is along the south coast of Devon Island, rather than offshore or along Bylot and Baffin islands. During the westward migration in 1976, 72 percent of more than 2,200 animals seen were within 1.5 km of the coast of Devon Island; during the peak of migration in late June and July, the figure was 94 percent (Davis and Finley 1979). Observations from Cape Hay, Bylot Island, on the southern shore of the sound, also suggest

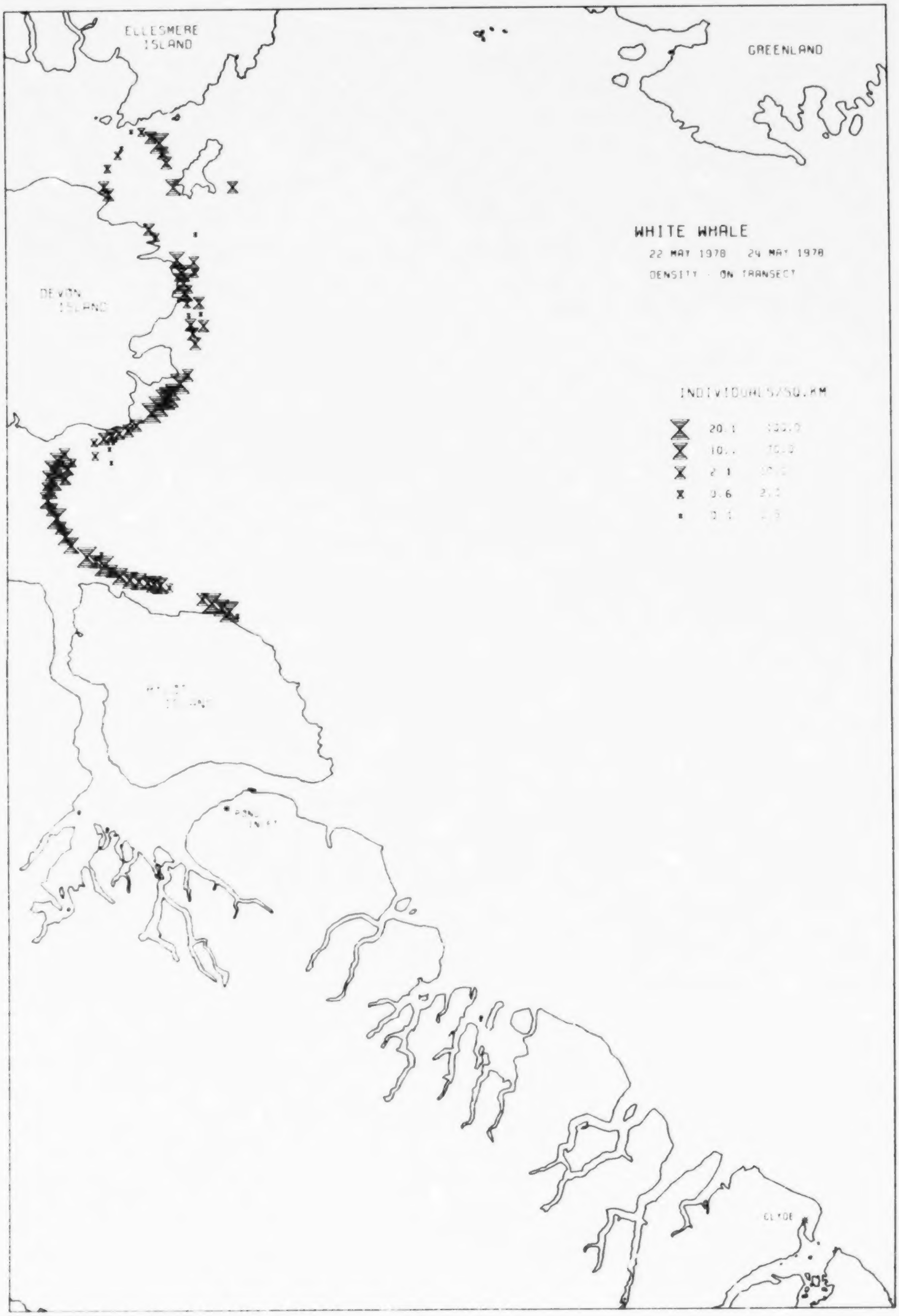

ELLESMERE ISLAND
GREENLAND
WHITE WHALE
22 MAY 1978 24 MAY 1978
DENSITY - ON TRANSECT
DEVON ISLAND
INDIVIDUALS/SQ.KM
20.1 100.0
10.1 20.0
2.1 10.0
0.6 2.0
0.1 0.5
BYLOT ISLAND
POND INLET
CLYDE

FIG. 2.8.1 White whale distribution in the study area, 22-24 May 1978. Densities shown are for four-min (≃12 km) transect segments. From Koski and Da (1979).

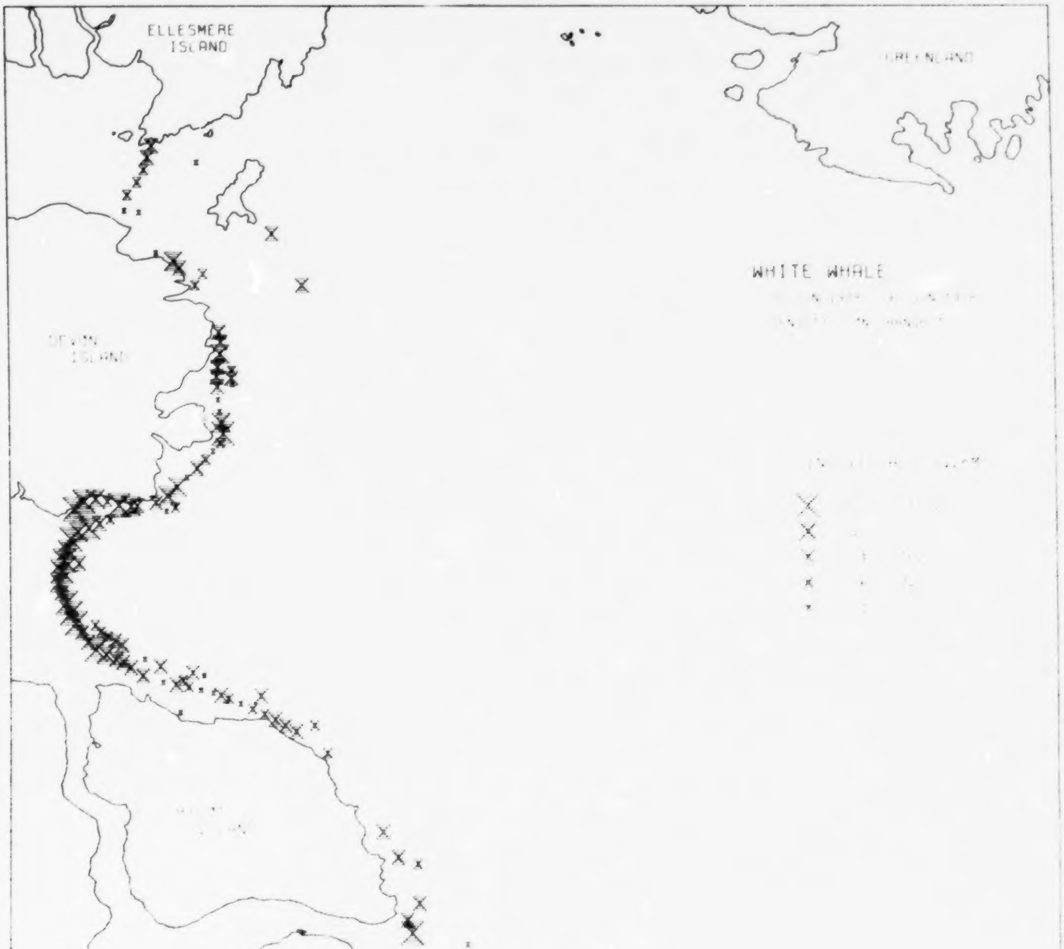

ELLESMERE ISLAND
GREENLAND
WHITE WHALE
DEVON ISLAND

FIG. 2.8.2 White whale distribution in the study area, 26-30 June 1978. Densities shown are for four-min (≃12 km) transect segments. From Koski and Davis (1979).

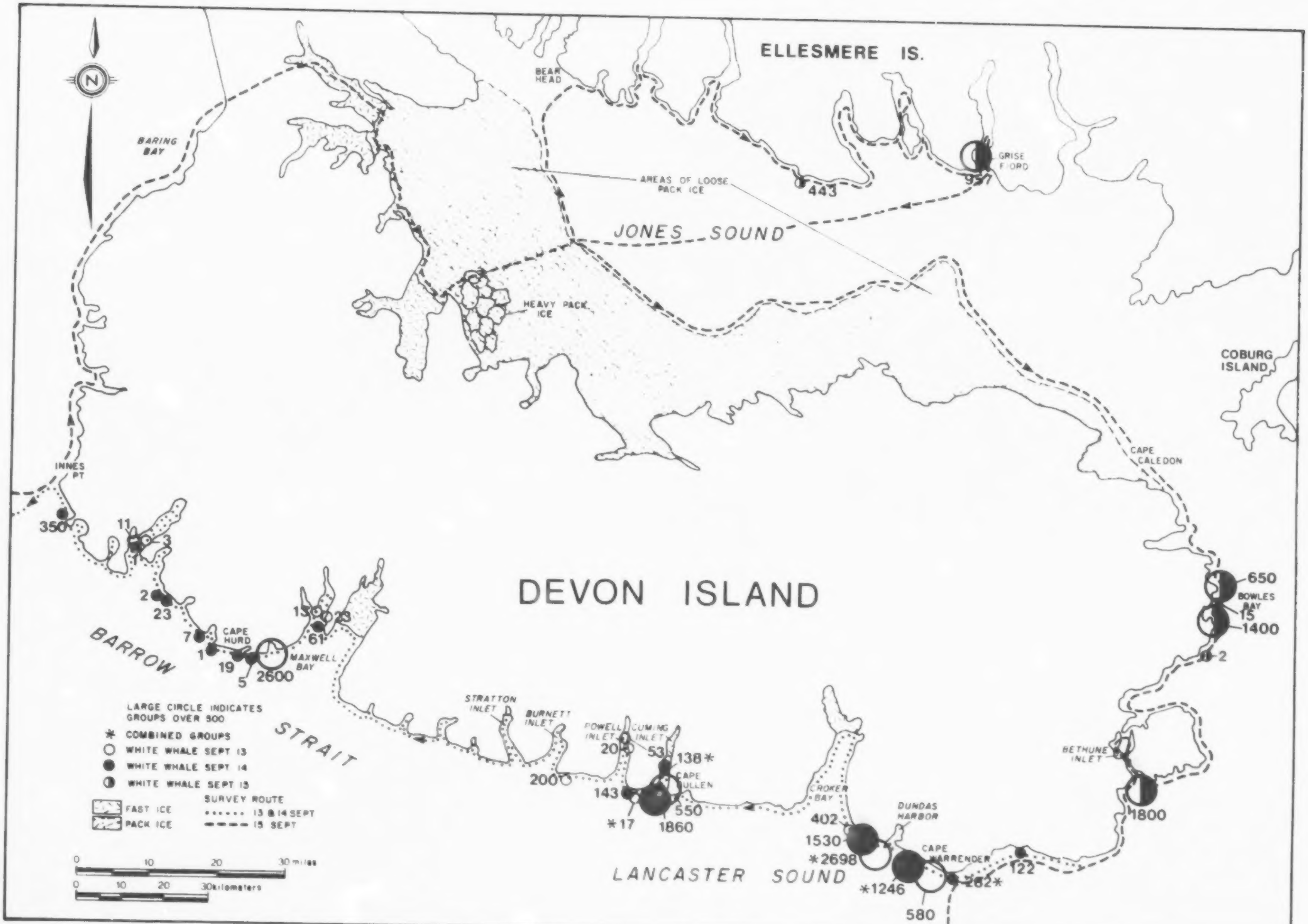

ELLESMERE IS.
BEAR HEAD
GRISE FIORD
937
443
AREAS OF LOOSE PACK ICE
JONES SOUND
HEAVY PACK ICE
BARING BAY
COBURG ISLAND
CAPE CALEDON
DEVON ISLAND
650
BOWLES BAY
15
1400
2
BETHUNE INLET
1800
122
262*
CAPE WARRENDER
580
*1246
DUNDAS HARBOR
402
1530
*2698
CROKER BAY
LANCASTER SOUND
138*
CAPE SULLEN
550
1860
*17
143
53
CUMING INLET
POWELL INLET
20
200
BURNETT INLET
STRATTON INLET
INNES PT
350
11
3
2
23
7
1
CAPE HURD
19
5
2600
MAXWELL BAY
13
61
23
BARROW STRAIT
LARGE CIRCLE INDICATES GROUPS OVER 500
* COMBINED GROUPS
○ WHITE WHALE SEPT 13
● WHITE WHALE SEPT 14
◐ WHITE WHALE SEPT 15
FAST ICE
PACK ICE
SURVEY ROUTE
13 & 14 SEPT
15 SEPT
0 10 20 30 miles
0 10 20 30 kilometers
N

FIG. 2.8.3. White whale sightings along coasts of Devon and Ellesmere islands, 13-15 September 1978. From Koski and Davis (1979).

white whales migrate along that coast. Less than 200 animals were seen there during almost 400 hours of observation from 21 June to 28 July 1976 (Greendale and Brousseau-Greendale 1976), and only 30-40 were seen there during incidental observations from 11 June to 20 August 1957 (Tuck 1957). Thus, the large numbers present in the southern part of the sound in 1978 and 1979 were an exception, rather than a regular occurrence.

White whales move west to the central arctic as soon as ice conditions permit, and by the end of July virtually all migrants have moved west to Barrow Strait. In 1976, no white whales were seen in eastern Lancaster Sound from late July to early September (Johnson et al. 1976b). In 1978, only four individuals were seen during surveys in eastern Lancaster Sound during August; 12 white whales seen along southeastern Ellesmere Island may have represented early fall migrants (Koski and Davis 1979). During summer, white whales move into shallow estuaries, especially around Somerset Island (Davis and Finley 1979). They do not move farther west than about 98°W (Finley 1976).

Eastward autumn migration of white whales is rapid, often involving large compact herds. It occurs during September, with a peak passage along south Devon Island in mid-September (Davis and Finley 1979). In 1976, white whales were seen in eastern Lancaster Sound from 12-28 September, with a maximum of about 2,500 animals observed on 19 September (Johnson et al. 1976b). In 1978, eastward migration was observed from 2 September on; the peak of migration was apparently on 13-15 September, when over 7,000 white whales were seen along the south coast of Devon Island (Fig. 2.8.3). Koski and Davis (1979) estimated that between 10,250 and 12,000 white whales moved through the study area in the fall of 1978. In 1979, 700-1,000 white whales were seen moving eastward along southeast Devon Island on 5 September, but peak passage apparently occurred on 14-18 September (Koski and Davis 1980a). Migration in 1979 is also believed to have been more protracted than in 1976 or 1978.

Eastward migration is almost exclusively along the southern coast of Devon Island, and most animals stay very close to the coastline (within 200 m). Many animals linger along the glacier fronts and coastline from Croker Bay to Bethune Inlet to feed. Concentrations of white whales totalling 1,800 animals in Bethune Inlet and 2,136 animals in the Dundas Harbour area were seen on 15 and 13 September 1978, respectively (Koski and Davis 1979).

After leaving Lancaster Sound, virtually all white whales turn north along the east coast of Devon Island towards the mouth of Jones Sound, presumably retracing their route of spring migration. Some, however, enter Jones Sound, as evidenced by sightings of several hundred animals along the north shore in 1978 (Fig. 2.8.3). White whales migrate south past Thule in late October (Vibe 1950), and on the basis of harvest statistics the peak of passage along the north-central coast of Greenland (75°-72°N) is in October and November (Kapel 1977).

The reproductive potential of white whales is not well understood because there is uncertainty about the validity of the method used to age the animals. Age is determined by counting the number of dentinal layers in the teeth. It is believed that two layers are laid down per year (Brodie 1971; Sergeant 1973a) although Ohsumi (1979) suggests that only one layer is added per year. This question is unresolved, although recent data presented to the Scientific Subcommittee of the International Whaling Commission favour the original interpretation of the two layers per year.

Depending upon which ageing criterion is correct, the age of first breeding in female white whales is either five or ten years, and the average life span is either about 25 or about 50 years. Females have a single calf every third year in the eastern Arctic (Brodie 1971), although there is some evidence for a calving interval of two years for some belugas in Alaskan waters (Braham 1979). Calves are born during summer. It is clear that the reproductive potential is low and white whale populations would take many years to recover population losses.

2.8.2 Narwhal

The narwhal (Monodon monoceros) is a small toothed whale that occurs in arctic waters of eastern Canada and western Greenland. The population that occurs in the eastern Lancaster Sound-western Baffin Bay area winters in Baffin Bay and Davis Strait and summers in fiords and channels in the eastern and central parts of the Canadian high arctic. The size of this population is not known; it has been estimated to number at least 20,000 individuals (Davis et al. 1978a; Koski 1980a), although this estimate is 'unacceptably vague' (Davis 1981:10).

The winter distribution of narwhals is only partially known. Recent surveys (McLaren and Davis 1981) revealed that narwhals are widespread during winter in southern Baffin Bay and throughout ice covered areas of Davis Strait. Their centre of abundance appears to be in the close pack ice in northwest Davis Strait, where they inhabit cracks and leads. It is possible that narwhals are present in winter throughout Baffin Bay in areas where suitable habitat exists. Athough Mansfield et al. (1975) suggested that narwhals wintered in the North Water of Baffin Bay, Finley and Renaud (1980) recorded only one group of 12 animals during surveys in March 1978 and 1979.

Northward migration to summering areas begins in March. Vibe (1950) believed that a major migration route followed the shore leads up the west side of Greenland to Melville Bay and Thule; narwhals appear near Thule in late May or in early June (Vibe 1950). However, there is a major broad-front movement in June through offshore Baffin Bay toward Lancaster Sound. Although narwhals seen in southern Baffin Bay in late March 1981 were already exhibiting strong northwest movements (McLaren and Davis 1981), the peak of passage through Baffin Bay appears to be in May and June. Koski (1980a) found narwhals to be widespread throughout offshore Baffin Bay from early May until late June (Fig. 2.8.4). Some of these animals move directly from offshore areas into Lancaster Sound. However, some animals move to the fast ice edge along the east side of Baffin Island in late June and then proceed northwest along that ice edge towards Bylot Island (Fig. 2.8.5). A regular lead generally does not develop along this ice edge until late June. Other animals arrive at east Devon Island whence they move north along the ice edges across Jones Sound and Glacier Strait, probably to Smith Sound. Almost 500 narwhals were present along the fast ice edge across Jones Sound on 20 June 1978 (Fig. 2.8.5). Over 1,500 were seen along the ice edge off eastern Ellesmere Island and across Smith Sound on 5 July 1978, although it is not known how those animals arrived there.

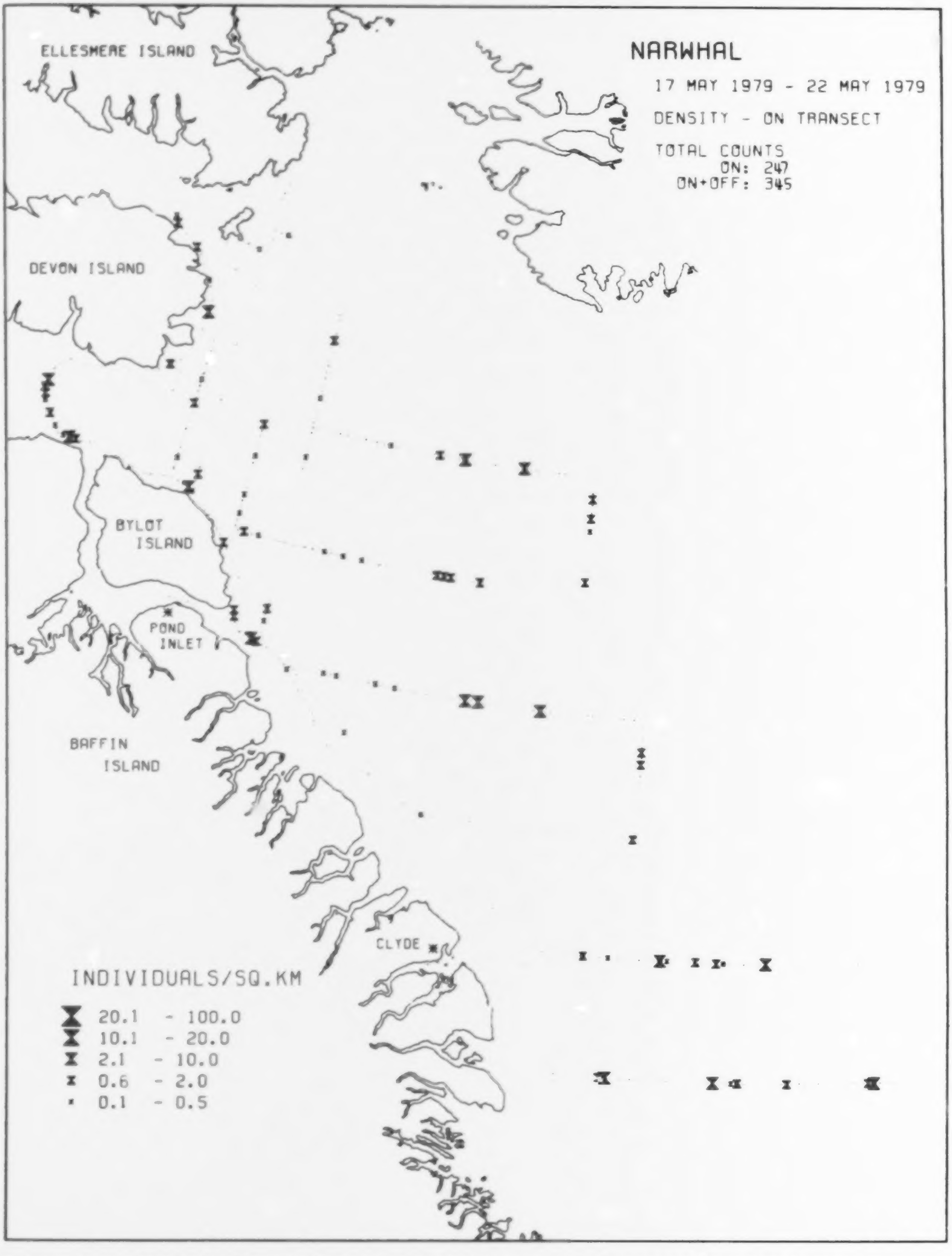

NARWHAL
17 MAY 1979 - 22 MAY 1979
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 247
ON+OFF: 345
ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
INDIVIDUALS/SQ.KM
20.1 - 100.0
10.1 - 20.0
2.1 - 10.0
0.6 - 2.0
0.1 - 0.5

FIG. 2.8.4 Narwhal distribution in the study area, 17-22 May 1979. Densities shown are for four-min (≈12 km) transect segments. From Koski (1980a).

FIG. 2.8.5 Narwhal distribution in the study area, 19-23 June 1978. Densities shown are for four-min ($\simeq 12$ km) transect segments. From Koski and Davis (1979).

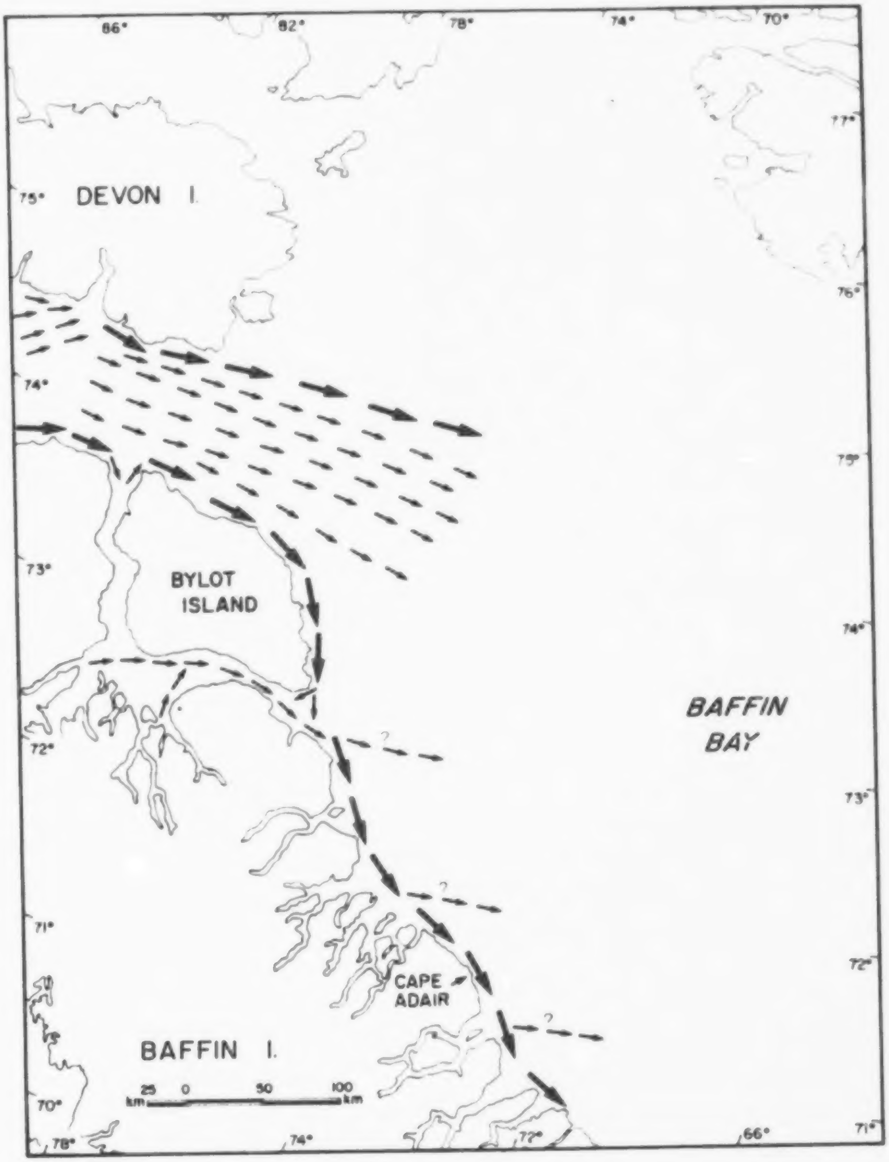

86°
82°
78°
74°
70°
77°
75°
DEVON I.
76°
74°
75°
73°
BYLOT ISLAND
74°
BAFFIN BAY
72°
?
73°
71°
?
72°
CAPE ADAIR
?
BAFFIN I.
25 km 0 50 100 km
70°
71°
78°
74°
72°
66°

FIG. 2.8.6 Known or suspected fall migration routes of narwhals. From Koski and Davis (1980).

A few narwhals reach Lancaster Sound in May; these animals are widely distributed throughout the sound, in densities much lower than in Baffin Bay (Koski 1980a). Most of the movement into and through the sound is in June and July. In 1976, when no fast ice edge was present across the sound, large numbers of narwhals entered between 24 June and 14 July, and smaller numbers continued to enter until the end of July. During this period, 21 percent of the narwhals entered along the north coast, 22 percent were along the south side and 57 percent were offshore (>seven km from a coastline) (Davis et al. 1978a). In 1978 and 1979, when a fast ice edge extended across eastern Lancaster Sound, narwhals were not numerous until mid-June, after which several hundred animals were seen regularly along the ice edge, and others were widespread offshore. In years when a fast ice edge is present, narwhals exhibit a great deal of back-and-forth movement along the fast ice edge between the coasts of Bylot and Devon islands until the ice edge breaks up. Herds of several hundred animals may be present along the edge at this time: on 30 June 1979, almost 400 animals were counted along the edge (Koski 1980a). An additional 2,200 animals were estimated to be offshore in Lancaster Sound at that time.

The movement of narwhals along Baffin Island and through Lancaster Sound to summering areas in the central arctic continues from late June through July. However, when an ice edge is present, the peak of movement may be up to a month later. In 1978, for example, narwhals were commonly seen moving into eastern Lancaster Sound as late as 9 August (Koski and Davis 1979). In 1976, on the other hand, few narwhals were seen in the eastern part of the sound after late July (Johnson et al. 1976b).

From mid-July to mid-September, narwhals are present in many of the deep water fiords and channels off Parry Channel and Baffin Bay. Most narwhals do not move as far west into the archipelago as do white whales. Certain fiords along northern Baffin Island, especially Eclipse Sound-Milne Inlet and Admiralty Inlet, have been traditionally occupied by narwhals. It is believed that these areas serve some function in calving since the peak of calving occurs in July and August (Finley et al. 1980; Finley and Miller 1982). Surveys in late August 1978 found about 600 narwhals in Milne Inlet and about 7,000 narwhals in Admiralty Inlet (Koski and Davis 1979).

Eastward migration of narwhals from summering areas begins in mid-September, and by the end of September large numbers are present in eastern Lancaster Sound. An estimated 7,000 animals were in this area on 25-26 September 1976 (Johnson et al. 1976b). At that time, narwhals were present along both the north and south shores of Lancaster Sound as well as in the middle of the sound. In 1979, several hundred narwhals migrated along the south coast of Devon Island between 12 and 26 September. After leaving the coast of Devon Island, these animals probably moved east or southeast into Baffin Bay (Koski and Davis 1980).

Although narwhals can occur throughout Lancaster Sound during autumn migration, numbers and densities are higher along the south side. A major migration route follows the north and east coasts of Bylot Island and the northeast coast of Baffin Island (Fig. 2.8.6). Several hundred individuals were seen at the mouth of Navy Board Inlet on 24 September 1978 and along the north coast of Bylot Island on 29 September 1978 (Koski and Davis 1979). Over 4,000 were counted in eastern Pond Inlet on 1 October 1979 and almost 3,000 were seen along east Bylot Island on 2 October 1979 (Koski and Davis

1980). About 5,000 narwhals were counted swimming south past Cape Adair, on the northeast coast of Baffin Island, between 29 September and 2 October 1978, and over 2,400 passed Cape Adair in October 1979.

In addition to the coastal movement along northeast Baffin Island in autumn, some narwhals from Lancaster Sound migrate through offshore Baffin Bay. The route of this offshore migration is not well documented. Also, an unknown number of narwhals summer in Smith Sound and these animals are thought to migrate south along the west coast of Greenland (Vibe 1950; Kapel 1977).

Most narwhals have left Lancaster Sound and northwest Baffin Bay by mid-October. Their status in Baffin Bay during the late fall and early winter is unknown.

Narwhals are apparently highly sociable animals. Although they are usually found in small, widely scattered herds, they are sometimes geographically concentrated in relatively small areas in groups of several hundreds or a few thousands. They are also temporally concentrated during migration when several thousands may migrate past a particular point during a two or three-day period (Greendale and Brousseau-Greendale 1976; Koski and Davis 1979, 1980). At such times and places, a substantial portion of the narwhal population would be potentially vulnerable to human influences.

The population dynamics of the narwhal are not well known (see Davis *et al*. 1980 for review) but may be similar to those of the closely related white whale (Mansfield *et al*. 1975a). The available information suggests that the reproductive rate is low and that narwhals would recover slowly from artificial reductions in population size.

2.8.3 Bowhead Whale

The bowhead whale (*Balaena mysticetus*) is an arctic baleen whale that can be up to 20 m in length. Formerly common in the eastern arctic, that population was severely reduced by intensive commercial whaling from the early 1700's to about 1915. Ross (1979) examined old whaling records that accounted for a harvest of over 28,000 eastern arctic bowheads between 1711 and 1911. The total kill was considerably larger. In spite of complete protection in the last 60 years, the population is thought to number only a few hundred individuals (Koski and Davis 1979; Davis and Koski 1980). Much of the remnant eastern arctic population occupies northwest Baffin Bay and channels in the eastern part of the archipelago for several months of the year.

Much of the knowledge of the winter distribution and migration of this population comes from historical accounts of the 19th century whalers. Bowheads wintered along the edge of the pack ice in Davis Strait, off the mouths of Cumberland Sound and Hudson Strait, and along the north coast of Labrador (Brown 1868; Low 1906). Marin ID (1980) reviewed catch records from Greenland and found records of wintering bowheads off the Greenland coast from Disko Bay south to about 63°N. Turl (1977) spent 27 days on a ship in the Davis Strait pack ice in February and March 1976, and recorded a single bowhead off the coast of Greenland at about 68°N, 55°W. McLaren and Davis (1981) observed bowheads in the open pack ice off west Greenland between 67°N and 69°N in March 1981.

The whalers found that bowheads appeared along the west coast of Greenland in May in the vicinity of 65° to 70°N (Brown 1868). From here they moved north during early June along the west Greenland coast to Melville Bay where they reportedly crossed the northern edge of the 'middle pack' near latitude 71°30'N to northwest Baffin Bay (Low 1906). The whalers were unable to penetrate the ice in Baffin Bay and continued their journey through shore-leads along the coast of Greenland. The whalers crossed the north end of Baffin Bay and again met with the bowhead in July on the last major whaling grounds in northwestern Baffin Bay, particularly around Lancaster Sound (Brown 1868; Lubbock 1937). Although many whales penetrated westward into Barrow Strait and Prince Regent Inlet, the largest numbers were found in the vicinity of Pond Inlet and Eclipse Sound (Brown 1868) and east and southeast of Bylot Island (Ross and MacIver 1981).

In 1978, bowhead whales were seen in the study area as early as 9 May when individuals were seen in Lancaster Sound (Koski and Davis 1979). Only five of nine animals seen in eastern Lancaster Sound and east of Devon Island were seen after mid-June (Fig. 2.8.7); on the other hand, only two of 25 bowheads observed in areas south of Lancaster Sound (including offshore Baffin Bay) were seen before mid-June. This pattern suggests that early-arriving bowheads reach Lancaster Sound from the north and east, presumably having crossed northern Baffin Bay north of 75°N. Later migrants (late June - early August), on the other hand, may have arrived at Lancaster Sound from the southeast, having travelled through the offshore pack ice in central and southern Baffin Bay.

In 1979, most bowheads seen were east or southeast of Lancaster Sound (Fig. 2.8.8) which might indicate that they followed a path similar to the early migrants in 1978 (see above). In 1979, no bowheads were seen in ice-free eastern Lancaster Sound prior to 12 July, and it may be that the whales remained in the pack ice of Baffin Bay until the break-up of the fast ice in the sound permitted movement to the west. In 1978, in contrast, bowheads were present in the pack ice in eastern Lancaster Sound in May.

Migration of bowheads into and through Lancaster Sound continues until early August, although most migrants have probably passed through by late July when ice conditions permit. In 1978, when fast ice blocked the sound until late July, bowheads were seen passing Cape Hay, Bylot Island, on 3, 5 and 6 August; these were the only sightings seen during more than 140 hrs of observations from 28 July to 9 August (Koski and Davis 1979). Migration is primarily offshore (>seven km from a coastline).

In August, most bowheads apparently move to nearshore summering areas and are virtually absent in eastern Lancaster Sound and Baffin Bay. Most of these sites are west of the study area in Creswell Bay, Prince Regent Inlet, Admiralty Inlet (Finley and Johnston 1977; Koski 1980b) but some individuals do summer in Eclipse Sound (Koski and Davis 1979). There is also a major summering area in and near Isabella Bay (69°30'N) along the east coast of Baffin Island: 22 individuals were recorded there on 13 September 1979 (Koski and Davis 1980).

Migration of bowhead whales from summering areas begins in late September, although most leave north Baffin Bay in early October. Migration is almost exclusively coastal; whales follow the south shore of Lancaster

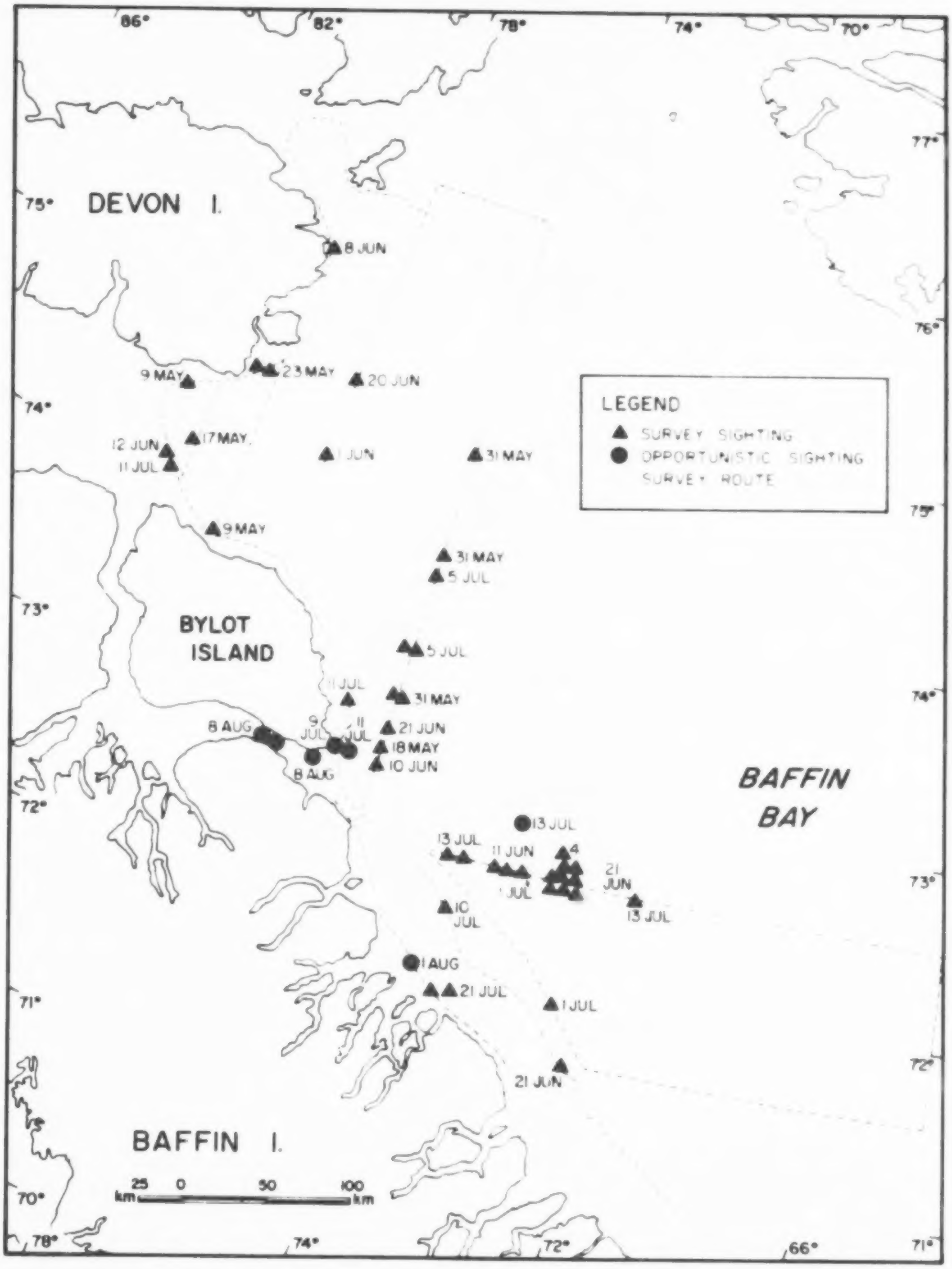

86°
82°
78°
74°
70°
77°
75°
DEVON I.
8 JUN
76°
9 MAY
23 MAY
20 JUN
74°
LEGEND
▲ SURVEY SIGHTING
● OPPORTUNISTIC SIGHTING
SURVEY ROUTE
12 JUN
17 MAY
11 JUL
1 JUN
31 MAY
75°
9 MAY
31 MAY
5 JUL
73°
BYLOT ISLAND
5 JUL
11 JUL
31 MAY
74°
8 AUG
9 JUL
11 JUL
21 JUN
18 MAY
10 JUN
8 AUG
BAFFIN BAY
72°
13 JUL
13 JUL
11 JUN
4
21 JUN
1 JUL
73°
13 JUL
10 JUL
1 AUG
71°
21 JUL
1 JUL
72°
21 JUN
BAFFIN I.
25 0 50 100
km km
70°
78°
74°
72°
66°
71°

FIG. 2.8.7 Bowhead whale sightings in the study area, 4 May-8 August 1978. From Koski and Davis (1979).

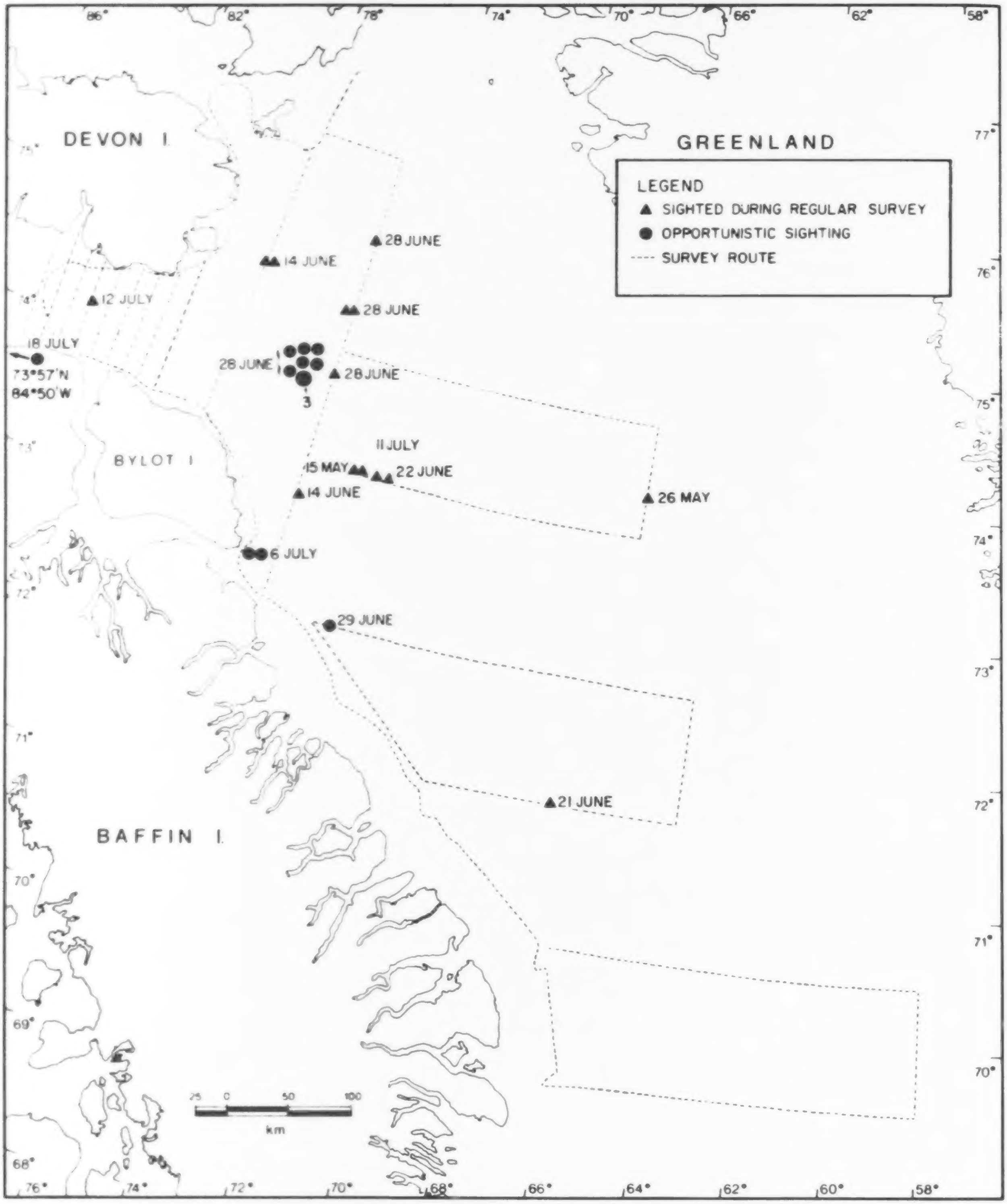

DEVON I.
GREENLAND
BYLOT I.
BAFFIN I.
LEGEND
▲ SIGHTED DURING REGULAR SURVEY
● OPPORTUNISTIC SIGHTING
---- SURVEY ROUTE
28 JUNE
14 JUNE
12 JULY
28 JUNE
18 JULY
73°57'N
84°50'W
28 JUNE
28 JUNE
3
11 JULY
15 MAY
22 JUNE
14 JUNE
26 MAY
6 JULY
29 JUNE
21 JUNE
km
25 0 50 100

FIG. 2.8.8 Bowhead whale sightings in the study area, 9 May-18 July 1979. From Koski (1980a).

Sound and then the east coasts of Bylot and Baffin islands. Movement out of Eclipse Sound proceeds northward through Navy Board Inlet to Lancaster Sound, and then southeast along the coast of Bylot Island. During aerial surveys in late 1978, bowheads were seen along this coast between 24 September and 7 October (Koski and Davis 1979).

Shore-based observations were made from Cape Adair, northeast Baffin Island, in late September and October 1978 and 1979. In 1978, 40 whales (representing an estimated 94 animals after allowance for periods of poor visibility) passed Cape Adair from 20 September to 7 October; in 1979, 41 whales (representing an estimated 92 animals) passed the cape from 28 September to 16 October. No bowheads were observed in areas away from the coasts of Bylot and Baffin islands during aerial surveys in these periods. All bowheads sighted were within 1.5 km of the coastline, and movements were all parallel to the coastline or directly across the mouths of fiords (Koski and Davis 1980). Bowheads migrate either singly or in small groups. The largest group recorded from Cape Adair was five animals.

The dynamics of bowhead populations are unknown. The species is presumed to have a low reproductive rate, based on (1) the low calf ratios (2-3.8 percent) noted in both the western and eastern arctic populations (Braham et al. 1979; Davis and Koski 1980; Renaud and Davis 1981) and (2) the lack of recovery in numbers during the 65 years since intensive whaling ceased.

2.8.4 Walrus

The walrus (Odobenus rosmarus) occupies a discontinuous circumpolar range. The Atlantic walrus (O. r. rosmarus) occurs in the eastern Lancaster Sound-western Baffin Bay area in both winter and summer.

Walruses that summer in the study area probably winter in northern Baffin Bay. About 700 animals were present on the pack ice off southeast Ellesmere Island in March 1979 (Finley and Renaud 1980); Vibe (1950) reported that walruses winter in the Thule District of Greenland. Walruses may also winter in the Jones Sound-Glacier Strait area, and northwest of the study area. Almost 200 were counted in winter near polynyas in Queen's Channel, Penny Strait, and at the west end of Jones Sound (Davis et al. 1978b). Walruses do not overwinter regularly in Lancaster Sound; a report of small numbers overwintering at Dundas Harbour in 1949-50 (Lawrie 1950) is exceptional. Walruses also winter off the central west coast of Greenland (McLaren and Davis 1981) but there is no evidence to suggest that these animals move to the study area in summer.

Walruses are present in the area in early May. In May of both 1978 and 1979, animals were seen regularly during surveys along the east coast of Devon Island, and in the Jones Sound-Coburg Island area. In fact, they are probably present in these areas in April; RRCS (1977) noted six animals along the south coast of Devon Island on 20 April 1976. These early migrants presumably came from wintering areas off eastern Ellesmere Island.

Walrus numbers in the study area increase through June to a peak in July. In 1979, over 300 animals were seen in eastern Lancaster Sound during a survey on 9-15 July (Fig. 2.8.9), primarily along the south coast of Devon Island. In 1978, peak numbers recorded during any one survey were seen on 28 July-2 August when over 480 walruses were seen, primarily along east Devon Island and in the eastern Jones Sound-Coburg Island area (Fig. 2.8.10). In both areas, the animals present were likely migrants waiting for the fast ice in Lancaster Sound and in Jones Sound to disintegrate so they could continue their westward migration. After the fast ice had moved out of Lancaster Sound in mid- to late July 1978 and 1979, few walruses were counted along the south coast of Devon Island.

During migration in May to July, very few walruses occur along coastlines south of Lancaster Sound, or in offshore waters. Little or no northwestward migration occurs along the east coast of Baffin Island or through offshore waters of central Baffin Bay. Rather, migration into the study area comes from the northeast, from the wintering areas in northern Baffin Bay and west Greenland; animals from Greenland cross northern Baffin Bay or Smith Sound.

By late July or early August, most walruses are at summering areas. Although many migrate through Lancaster Sound to sites in the central arctic (Gunn 1949; Finley et al. 1974; Davis et al. 1978b), some walruses do summer

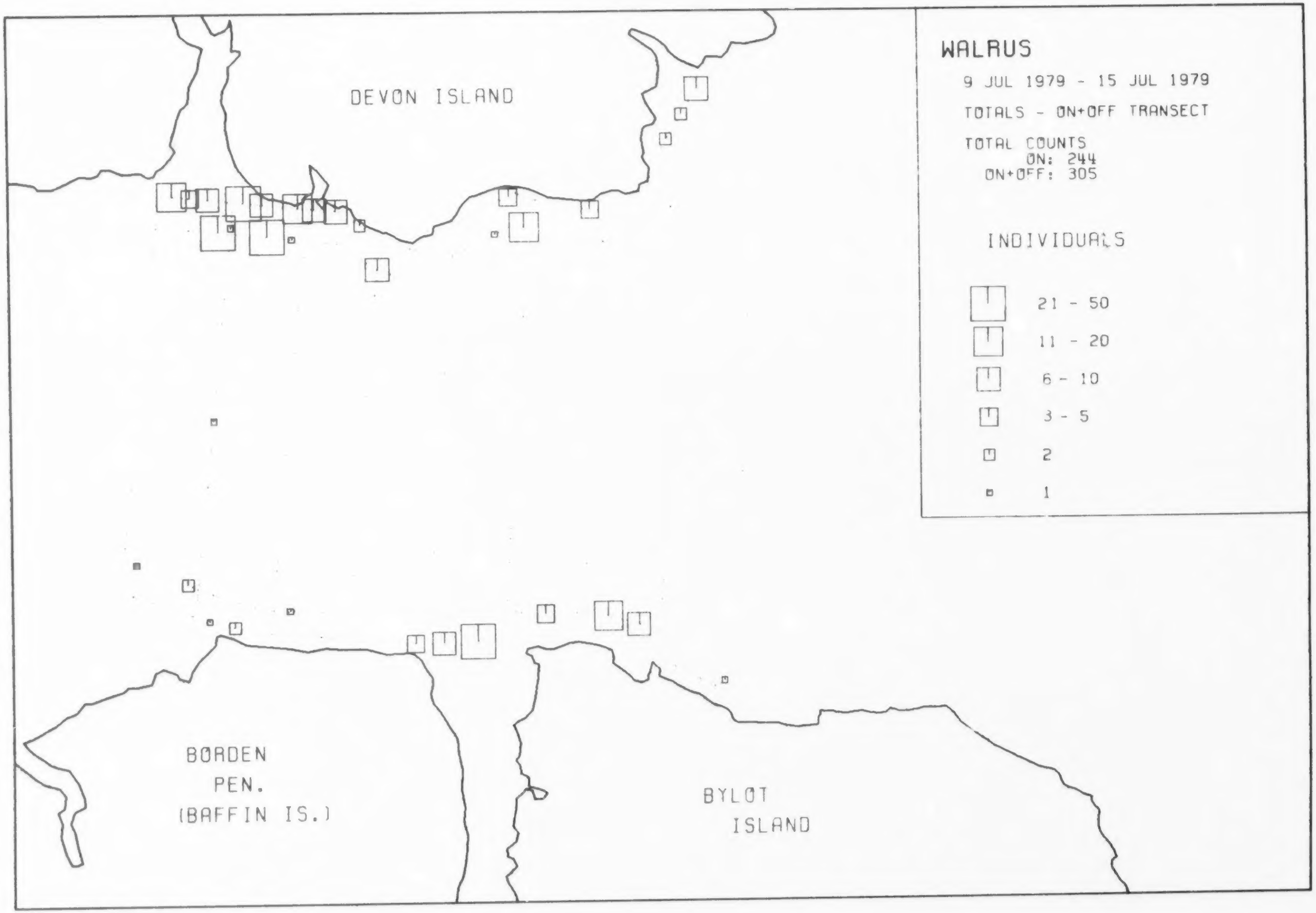

WALRUS
9 JUL 1979 - 15 JUL 1979
TOTALS - ON+OFF TRANSECT
TOTAL COUNTS
ON: 244
ON+OFF: 305
INDIVIDUALS
21 - 50
11 - 20
6 - 10
3 - 5
2
1
DEVON ISLAND
BØRDEN PEN. (BAFFIN IS.)
BYLOT ISLAND

FIG. 2.8.9 Walrus distribution in eastern Lancaster Sound 9-15 July 1979. Numbers shown are for two-min ($\simeq$six km) transect segments. From Koski (1980a).

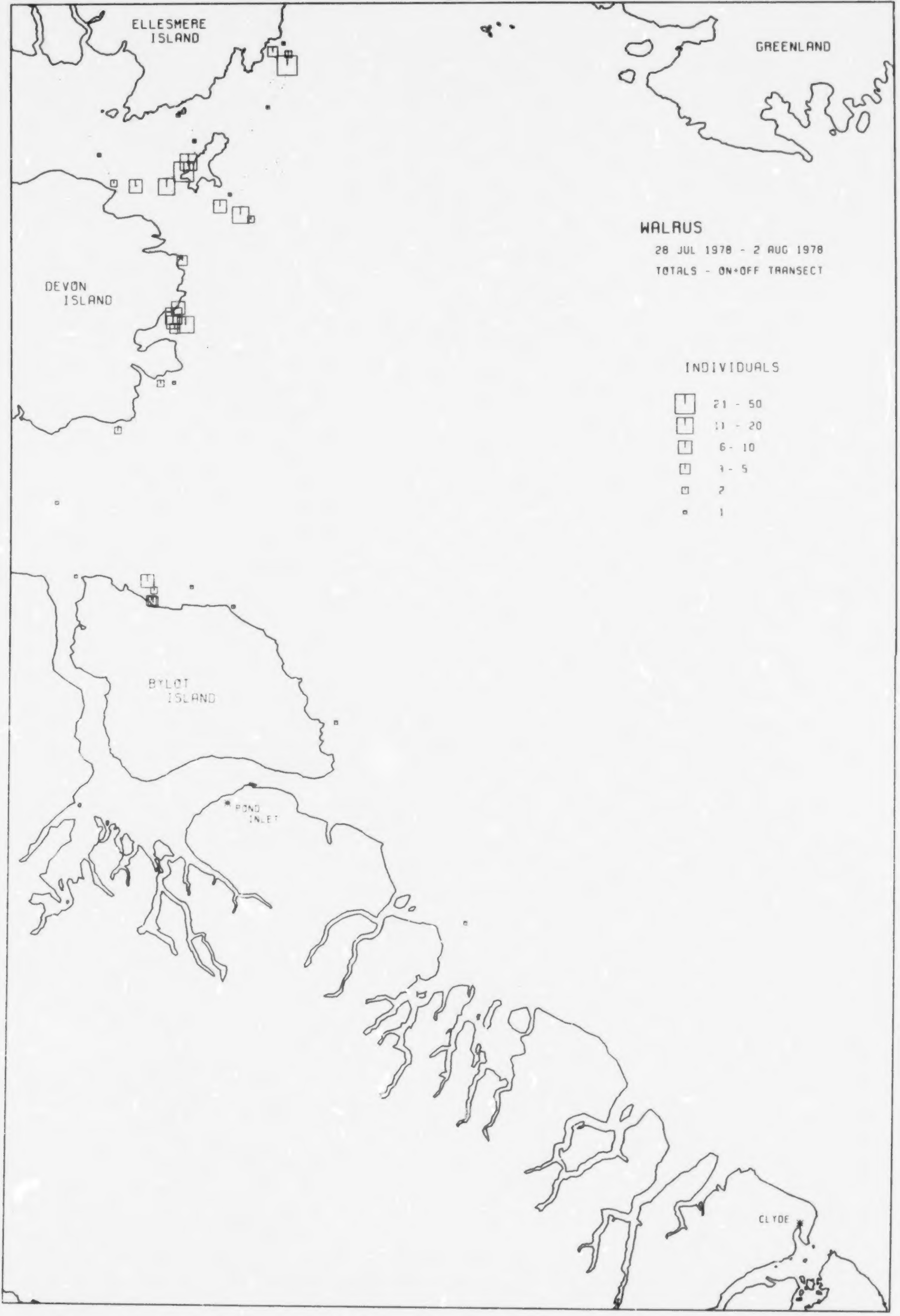

ELLESMERE ISLAND
GREENLAND
WALRUS
28 JUL 1978 - 2 AUG 1978
TOTALS - ON+OFF TRANSECT
DEVON ISLAND
INDIVIDUALS
21 - 50
11 - 20
6 - 10
3 - 5
2
1
BYLOT ISLAND
BOND INLET
CLYDE

FIG. 2.8.10 Walrus distribution in the study area, 28 July-2 August 1979. Numbers shown are for four-min (≃12 km) transect segments. From Koski and Davis (1979).

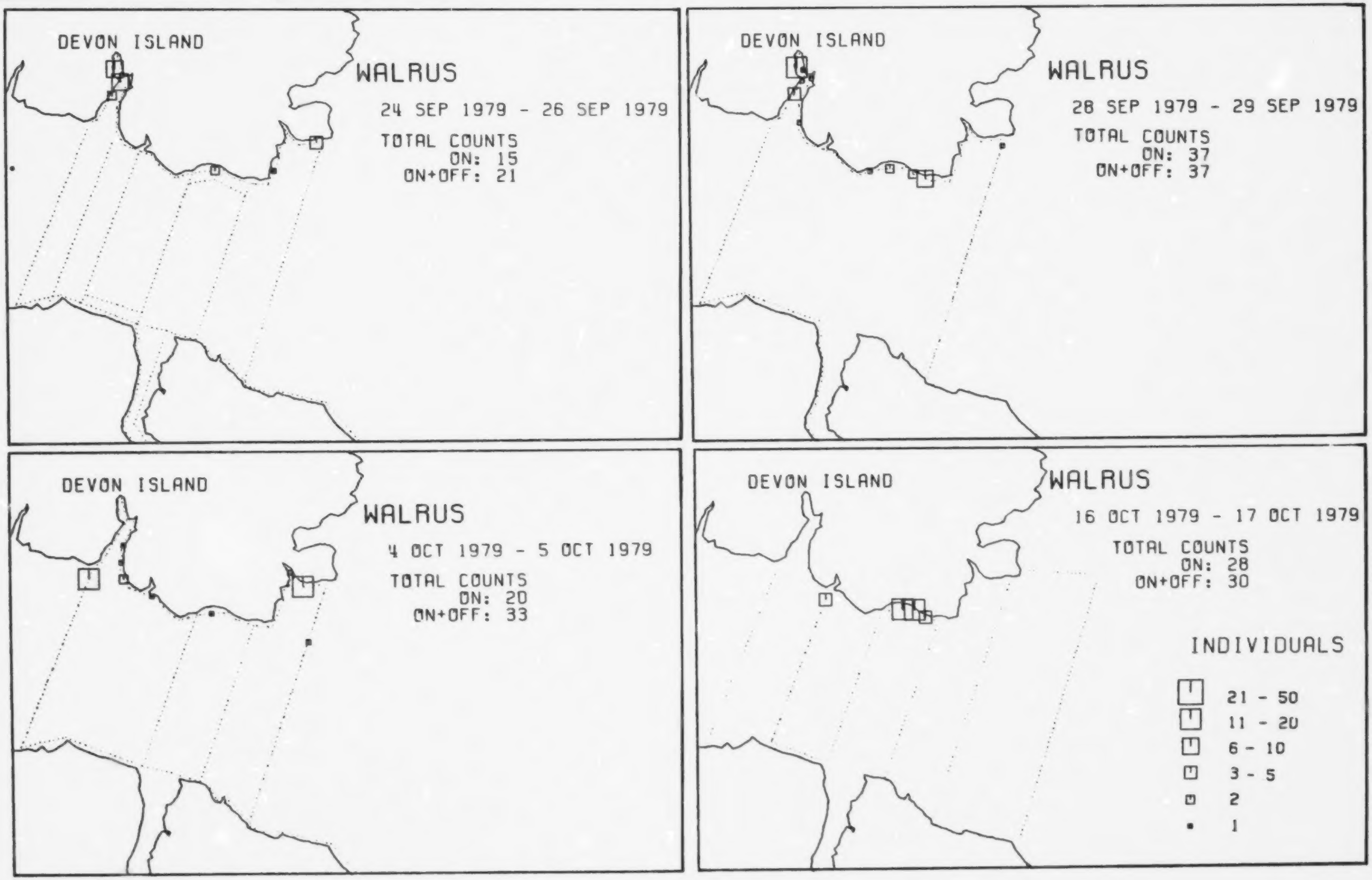

DEVON ISLAND
WALRUS
24 SEP 1979 - 26 SEP 1979
TOTAL COUNTS
ON: 15
ON+OFF: 21
DEVON ISLAND
WALRUS
28 SEP 1979 - 29 SEP 1979
TOTAL COUNTS
ON: 37
ON+OFF: 37
DEVON ISLAND
WALRUS
4 OCT 1979 - 5 OCT 1979
TOTAL COUNTS
ON: 20
ON+OFF: 33
DEVON ISLAND
WALRUS
16 OCT 1979 - 17 OCT 1979
TOTAL COUNTS
ON: 28
ON+OFF: 30
INDIVIDUALS
21 - 50
11 - 20
6 - 10
3 - 5
2
1

FIG. 2.8.11 Walrus distribution in eastern Lancaster Sound, 24 September-17 October 1979. Numbers shown are for two-min (≃six km) transect segments. Modified from Koski and Davis (1980).

in the eastern Lancaster Sound-western Baffin Bay region. A major area includes the shallow waters along the east coast of Devon Island. Herds of walruses were seen regularly in bays and inlets along the entire length of this coast from early August until mid-September 1978. Other summering areas include the southeast coast of Ellesmere Island, particularly near Cape Norton Shaw; the west coast of Coburg Island (Koski and Davis 1979); and Croker Bay along south Devon Island (Koski 1980b). There have been no other important summering areas in the study area during recent years, although Miller (1955) reported that 200-300 animals summered near the Wollaston Islands, at the entrance to Navy Board Inlet.

Walruses probably do not leave summering areas until forced to by freeze-up. Migration probably starts in early October. However, there are few data to document this movement. Small numbers were seen along the south shore of Devon Island (east from Croker Bay) during surveys from 24 September to 5 October 1979, and 27 animals were observed along a 20-km stretch of southeast Devon Island on 16 October 1979 (Fig. 2.8.11). It is possible that the main eastward fall migration from western Lancaster Sound and Barrow Strait was occurring at this time. It is presumed that autumn routes in Baffin Bay retrace those of the spring migration.

Walruses feed primarily on bottom-dwelling invertebrates, especially bivalve molluscs (Fay _et al._ 1977; Davis _et al._ 1980). Thus, walruses are usually found in relatively shallow waters where they can dive to the bottom. It is not certain how deep walruses can dive, but Vibe (1950) believed they foraged only to depths of 80-90 m. However, overwintering walruses have been found in much deeper areas of northern Baffin Bay (Finley and Renaud 1980).

Walrus populations have been heavily exploited in historic times. Some populations of the Atlantic walrus have probably not recovered from this exploitation (see reviews by Reeves 1978; Davis _et al._ 1980). As walruses have a low reproductive rate (about 8 percent per year, Mansfield 1958), recovery from population losses is a slow process.

2.8.5 Harp Seal

The harp seal (_Phoca groenlandica_) occurs in three isolated breeding populations in the North Atlantic. The largest of these populations whelps and moults in spring on pack ice off southern Labrador and northern Newfoundland, and in the Gulf of St. Lawrence. The population is estimated to consist of about 1,250,000 animals (excluding pups) and produces about 300,000-350,000 pups per year (Lett _et al._ 1977). A proportion of these animals migrates north into the eastern Lancaster Sound-western Baffin Bay area in the summer.

Western Atlantic harp seals migrate north along the Labrador coast from the whelping and moulting areas off Newfoundland; they then probably continue northeastward along the pack ice edge across Davis Strait to Greenland (Sergeant 1965). Adults arrive along the southwest coast of Greenland in late May and June and juveniles arrive about two weeks later. Most young-of-the-year and sub-adults spend the summer in inshore areas between Disko Bay and Upernavik (Sergeant 1976a). Many adults continue up the west Greenland coast, reaching the Thule District in June and July. Few move farther north (Vibe 1950).

Substantial numbers of harp seals move to western Baffin Bay and enter Lancaster Sound. They arrive in western Baffin Bay in mid-June. They were first seen during aerial surveys on 15 June 1978 and 11 June 1979 (Koski and Davis 1979; Koski 1980a); both sightings were of groups migrating north along the fast ice edge off the east coast of Baffin Island. This ice edge is the major migration route for harp seals moving to Lancaster Sound, although how they arrive at the ice edge is not known. From mid-June until the end of August, there is a steady movement of harp seals migrating north along the east sides of Baffin and Bylot islands. During surveys in 1978, peak numbers were noted along Baffin Island from 26 June to 8 July and along Bylot Island from 3-11 July. In 1979, over 1,000 harp seals were seen along the east side of Baffin Island during a survey on 13 July (Fig. 2.8.12).

Harp seals entering Lancaster Sound appear to be mostly adults (Greendale and Brousseau-Greendale 1976). They travel in groups of up to 100 animals (Johnson et al. 1976b; Riewe 1977). Numbers entering Lancaster Sound apparently vary from year to year. Tuck (1957) estimated that 150,000 harp seals moved west past Cape Hay, Bylot Island, from late June to early August 1957, but Greendale and Brousseau-Greendale (1976) counted only 16,000 animals passing the same point from mid-July to late July 1976. In that year, harp seals were first recorded during aerial surveys on 4 July (Johnson et al. 1976b). In both 1978 and 1979, harp seals were first seen in the sound on 19 June (Koski and Davis 1979; Koski 1980a); over 1,200 animals were seen along the ice edge across Navy Board Inlet and in the southern half of Lancaster Sound on 11 July 1978 (Koski and Davis 1979). Based on simple extrapolations of densities recorded during aerial surveys, Koski (1980b) estimated that 2,400 harp seals were in eastern Lancaster Sound on 9-15 July 1979 (cf. Fig. 2.8.12).

Few of the harp seals that enter Lancaster Sound move as far west as Barrow Strait (Finley 1976). Koski (1980b) estimated that about 4,000 animals were in Barrow Strait east of 94°W in late August and early September 1979. They were offshore, often in small schools, and often associated with pan ice. Over 3,500 were estimated to be in Admiralty Inlet on 24 August 1978 (Koski and Davis 1979). Many of the harp seals entering Lancaster Sound cross the sound; the small numbers seen in offshore waters during surveys in 1976, 1978 and 1979 suggest that most of the crossing occurs west of the study area. Many harp seals leave the sound by travelling eastward along the north side, and then north along the coasts of Devon and Ellesmere islands. This exodus occurs mainly in September. However, animals seen along east Devon Island in late July 1978 (Fig. 2.8.13) may have been animals that were deflected northward immediately after entering Lancaster Sound by the presence of fast ice in the sound.

During surveys on 21 and 28 July 1978, several hundred harp seals were seen along the fast ice edge across Glacier Strait, northeast of Coburg Island (e.g. Fig. 2.8.13). Animals were swimming both northward and southward. Some of these animals may have been continuing their northward movement from Lancaster Sound, whereas others may have been migrating to the Jones Sound area from Greenland via northern Baffin Bay or Smith Sound.

Most harp seals leave the study area in late September and early October. Almost 500 were counted moving northeast along southeast Ellesmere Island on 21 September 1978; the animals had presumably come from Jones Sound, where eastward migrating harp seals were seen on 15 September.

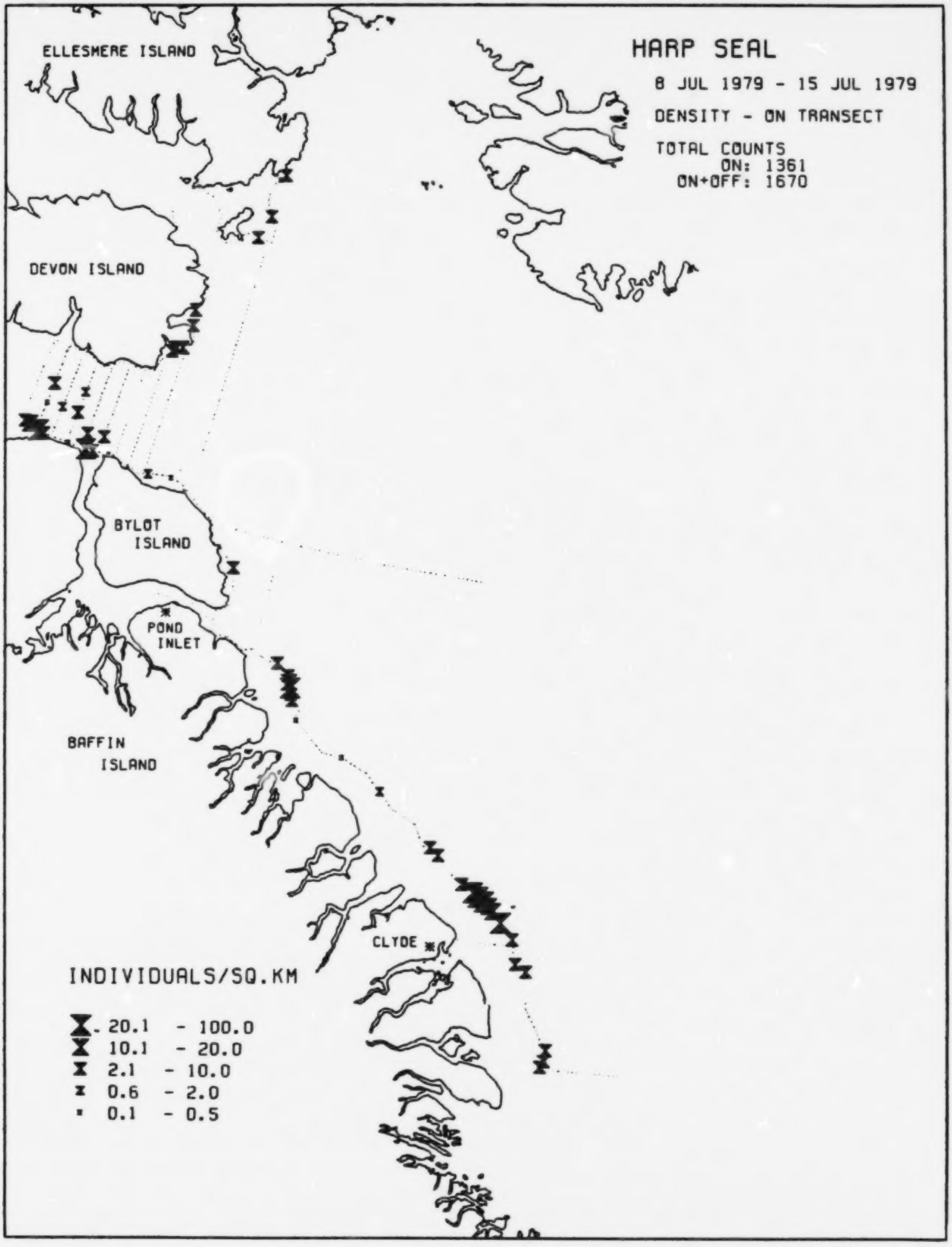

ELLESMERE ISLAND
HARP SEAL
8 JUL 1979 - 15 JUL 1979
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 1361
ON+OFF: 1670
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
INDIVIDUALS/SQ.KM
20.1 - 100.0
10.1 - 20.0
2.1 - 10.0
0.6 - 2.0
0.1 - 0.5

FIG. 2.8.12 Harp seal distribution in the study area, 8-15 July 1979. Densities shown are for four-min (≃12 km) transect segments. From Koski (1980a).

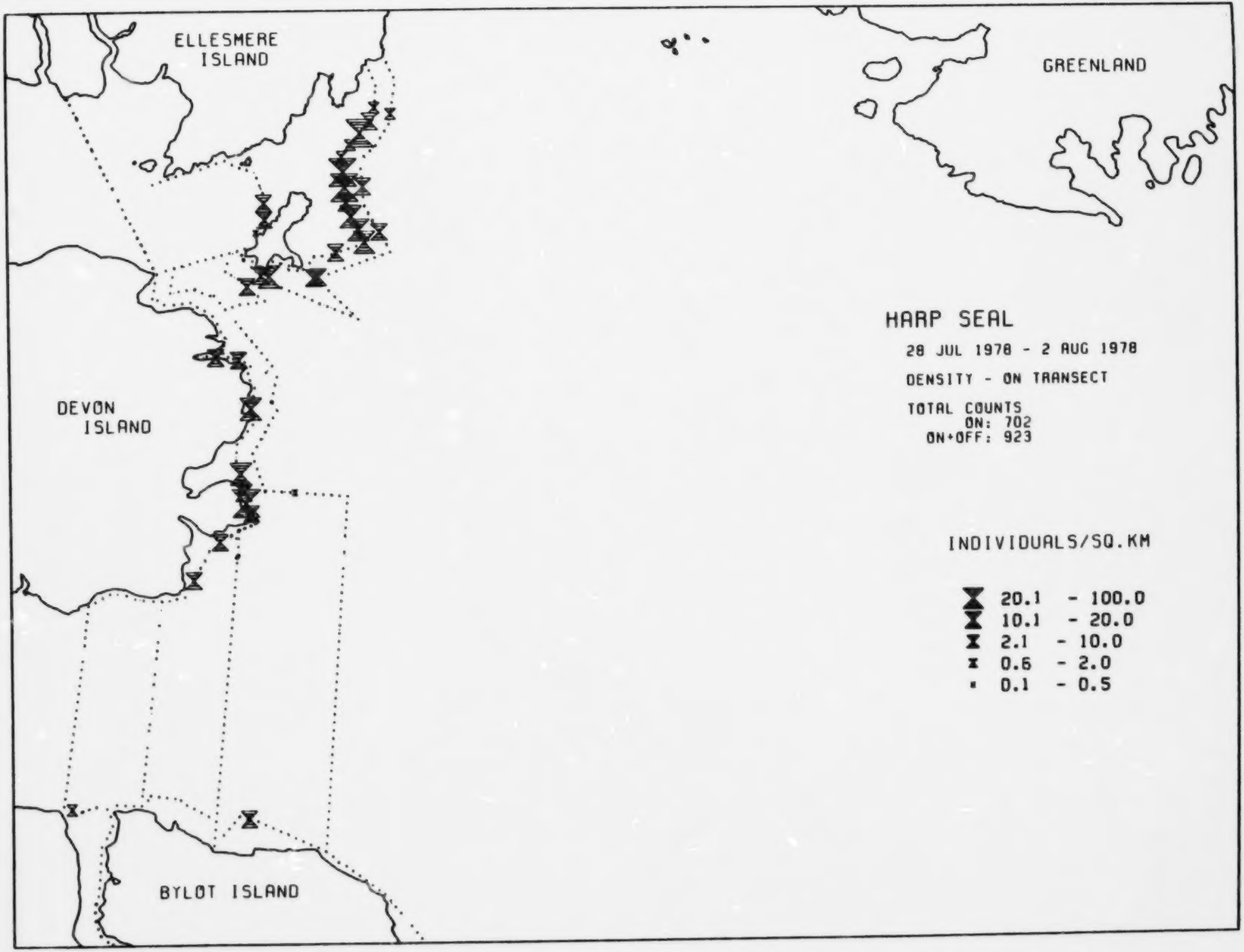

ELLESMERE ISLAND
GREENLAND
DEVON ISLAND
BYLOT ISLAND
HARP SEAL
28 JUL 1978 - 2 AUG 1978
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 702
ON+OFF: 923
INDIVIDUALS/SQ.KM
20.1 - 100.0
10.1 - 20.0
2.1 - 10.0
0.6 - 2.0
0.1 - 0.5

FIG. 2.8.13 Harp seal distribution in and north of Lancaster Sound, 28 July-2 August 1978. Densities shown are for two-min (≃six km) transect segments. From Koski and Davis (1979).

Migration out of Lancaster Sound may occur slightly later than out of Jones Sound. Although migration along the south, and then east, coasts of Devon Island continues, there is also a substantial movement along the south side of Lancaster Sound. Over 1,000 animals were seen at the northern end of Navy Board Inlet on 24 September 1978 (Koski and Davis 1979), and 1,500 were seen hauled out on pan ice at the mouth of Admiralty Inlet on 24 September 1979 (Koski 1980b). These animals apparently move southeast along Baffin Island, retracing the route of their spring migration. Over 1,800 animals were seen along the coasts of Bylot and Baffin islands on 1 October 1979 primarily at the mouths of Pond Inlet and Buchan Gulf. Most of these animals were associated with large groups of narwhals. This migration is not entirely restricted to the coastal waters. Only 46 percent of 37 migrating groups observed from shore at Cape Adair, Baffin Island, were within one km of the coast; animals were seen up to four km from the coastline (Koski 1980b). Some individuals also migrate south far offshore, although numbers may be lower than those near coasts. In both 1978 and 1979, densities of up to 0.1 seal/km^2 were recorded during surveys in offshore eastern Lancaster Sound in late September (Koski and Davis 1979; Koski 1980b). Johnson et al. (1976b) recorded similar densities in the same area in late September 1976. On 26 September 1978, a group of almost 1,000 harp seals was seen hauled out on pan ice about 40 km off the east coast of Bylot Island (Koski and Davis 1979). In 1979, migrating harp seals were seen up to 60 km offshore (Koski 1980b).

Harp seals were still present in eastern Lancaster Sound during the final survey on 16-17 October 1979 (Koski 1980b). Most have probably left the study area by late October, but some linger along southeastern Baffin Island and west Greenland well into the winter.

2.8.6 Ringed Seal

The ringed seal (Phoca hispida) is abundant and widespread in the Canadian Arctic. It is usually a permanent resident in most of its range; it overwinters under sea ice through which it maintains breathing holes (Degerbøl and Freuchen 1935; McLaren 1958; Smith 1973; Finley 1979). Ringed seals tend to be widely distributed; they rarely occur in large or dense aggregations in the eastern arctic, although 'zippers' of up to 70 seals may occur along cracks in fast ice areas.

Two seemingly distinct and reproducing populations of ringed seals occur in the eastern Lancaster Sound-western Baffin Bay area--a population on the coastal fast ice and a population on the offshore pack ice of Baffin Bay (Finley et al. 1982). Fast ice areas include Navy Board Inlet and Pond Inlet and the landfast ice shelf and fiords along the east side of Baffin Island (Fig. 2.8.14). Finley et al. (1982) found that densities on the ice shelf along east Baffin Island were 1.31 seals/km^2; densities on the fast ice in the fiords averaged 1.72 seals/km^2. An estimated 67,000 seals inhabit these two areas (Finley et al. 1982). Other areas of landfast ice (e.g. coastal areas of Lancaster Sound, Jones Sound) were not surveyed in 1978 and 1979.

Ringed seals are also common and widespread throughout the offshore pack ice in Baffin Bay. During peak haulout in late June 1979, the density in Baffin Bay averaged 1.39 seals/km^2 (Fig. 2.8.14; Finley et al. 1982). Finley et al. derived a rough estimate of about 400,000 seals in the Baffin Bay pack

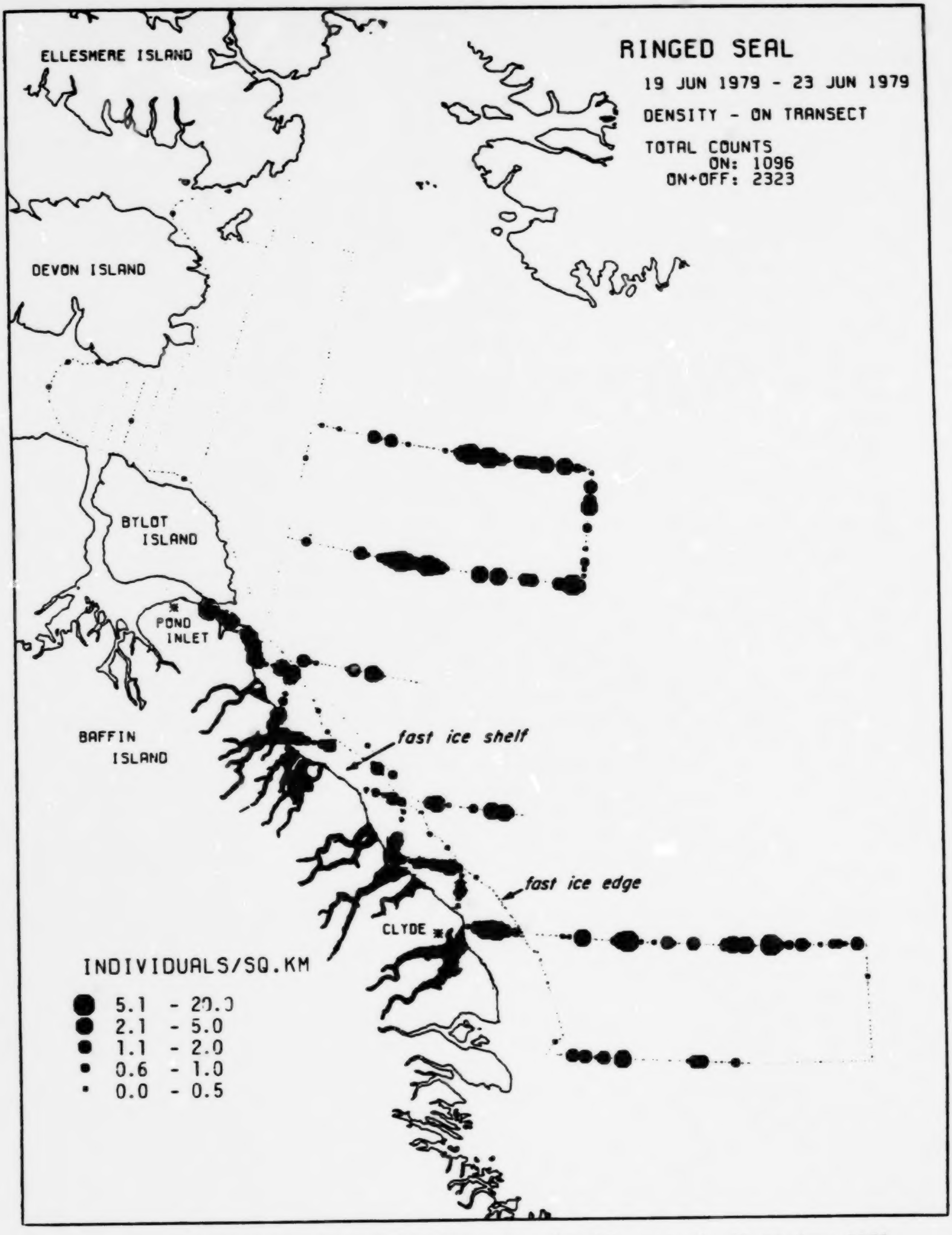

RINGED SEAL
19 JUN 1979 - 23 JUN 1979
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 1096
ON+OFF: 2323
ELLESMERE ISLAND
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
fast ice shelf
fast ice edge
CLYDE
INDIVIDUALS/SQ.KM
● 5.1 - 20.0
● 2.1 - 5.0
● 1.1 - 2.0
• 0.6 - 1.0
· 0.0 - 0.5

FIG. 2.8.14 Ringed seal distribution east of Baffin Island, 19-23 June 1979. Densities shown are for two-min (~six km) transect segments. Solid black areas denote fiords. From Koski and Davis (1979).

ice. Finley et al. provide morphological and ecological evidence that indicates that ringed seals of the pack ice and those of the fast ice are reproductively isolated. Pack ice seals are smaller than their fast ice counterparts and have a different diet and gut parasite load. Pack ice seals are thought to move into coastal areas during the brief open water period.

Ringed seal densities are substantially lower in Lancaster Sound than in Baffin Bay, probably because of the less stable pack ice in the sound. No seals were seen in eastern Lancaster Sound in spring 1979 until mid-July, when the fast ice broke up and started to move eastward. Densities in the sound averaged 0.01 seals/km^2 from 9 May-2 July 1979, but were 0.25 seals/km^2 on 9-15 July (Koski 1980a). In 1976, when pack ice was present in eastern Lancaster Sound, the surveyed density during the period of peak haulout was 0.21 seals/km^2 (Johnson et al. 1976b).

Breeding female ringed seals on fast ice hollow out birth layers under the snow on the ice; the young are born in late March or early April. In fast ice areas these lairs are in snow drifts in the lee of pressure ridges and hummocks (McLaren 1958; Smith and Stirling 1975; Smith 1976a). Lactation lasts for about six weeks, after which the female abandons the pup (McLaren 1958; Smith 1973). The duration of lactation may be partly a function of ice stability; Fedoseev (1975) found that ringed seals reproducing on pack ice in the Sea of Okhotsk nursed for only three weeks.

2.8.7 Bearded Seal

The bearded seal (Erignathus barbatus) is widely distributed throughout its circumpolar range. It is a solitary animal. Bearded seals are strongly associated with moving pack ice and, although capable of maintaining breathing holes in fast ice, they tend to avoid both fast ice and close pack ice (Burns and Frost 1979). Bearded seals are usually widely dispersed and are not known to occur in large aggregations, although they can be fairly common in certain types of pack ice. In some areas, bearded seals are quite sedentary and make only local movements in response to changing ice conditions (Vibe 1950; McLaren 1962; Fedoseev 1973), whereas in other areas regular long distance movements occur (Burns 1967; Benjaminsen 1973; Stirling et al. 1975, 1977a, 1979). There is some evidence of differential distribution and movements of different age classes (Benjaminsen 1973; Potelov 1975).

Bearded seals are widely distributed throughout eastern Lancaster Sound and western Baffin Bay from May until October, and probably occupy open water areas in this region prior to May and subsequent to October as well. Finley and Renaud (1980) recorded small numbers of bearded seals in March 1979 along the ice edge off southeast Ellesmere Island, a probable wintering area. Koski (1980a) suggested that most of the bearded seals in the study area winter on the offshore pack ice of Baffin Bay, although there are no data to substantiate this. McLaren and Davis (1981) saw bearded seals on the close pack ice in southern Baffin Bay and Davis Strait in March 1981.

During the spring and early summer (May-July), bearded seals are widely distributed throughout the offshore pack ice in Baffin Bay and Lancaster Sound. On 17-22 May 1979, pack ice was present throughout all of Baffin Bay, and bearded seals were widespread at an average density of 19 seals/1000 km^2

(Fig. 2.8.15). As the offshore pack ice drifted southeastward in that year, many seals apparently moved with the ice into southern and central Baffin Bay, where late June densities averaged 52 seals/1000 km^2 (Koski 1980a). Small numbers also moved into Lancaster Sound as far as the fast ice edge, but none was seen in the ice-free waters of northwest Baffin Bay or eastern Lancaster Sound.

In late June and July there is a movement from the offshore pack ice into areas along coasts and ice edges. In 1978, densities along the east side of Baffin Island doubled during the first half of July; in 1979, densities increased similarly between 19 June and 15 July, whereas densities in offshore areas decreased substantially.

In mid-and late July there is an apparent westward movement of bearded seals through eastern Lancaster Sound. Greendale and Brousseau-Greendale (1976) recorded 163 bearded seals migrating west past Cape Hay, Bylot Island, between 22 and 28 July 1976. Numbers seen during weekly aerial surveys in eastern Lancaster Sound in 1976 were highest on 25-26 July 1976 (Johnson et al. 1976b). An influx may have been occurring on 12-15 July 1979 when 12 seals were seen along the south side of the sound (Koski and Davis 1980).

During the ice-free season in August and September, bearded seals are found primarily along coasts. In 1978, up to 20 seals were seen regularly along the southeast coast of Ellesmere Island and along the east coast of Devon Island and Baffin Island. Most sightings in these areas were along the fronts of glaciers. Some animals also move into the fiords along east Baffin Island (Koski and Davis 1979; Koski 1980b).

Koski (1980b) detected an apparent movement of bearded seals through eastern Lancaster Sound from late September until mid-October, when surveys terminated. Densities varied from 23 to 41 seals/1000 km^2 in the sound during three surveys from 28 September to 17 October (Koski 1980b). Bearded seals were also seen along the coast of Bylot Island at this time. On 16-17 October 1979, bearded seals were seen along the coast of east Baffin Island, as seals from the fiords started to move out into the bay as ice began to form. No fall movements in eastern Lancaster Sound or western Baffin Bay were noted in 1978.

Bearded seals give birth to a single pup in late April and early May. Lactation lasts for only 12 to 18 days, after which time the pup is abandoned. Peak mating activity occurs in May, usually after the female has abandoned the pup (Burns and Frost 1979).

The bearded seal is primarily a benthic feeder and its distribution is somewhat determined by the presence of relatively shallow water. The depth to which bearded seals can dive is subject to some debate. Vibe (1950) gives a maximum depth of 80 m whereas Braham et al. (1977) list 200 m as the maximum depth. Stirling et al. (1977a) found that bearded seals preferred waters 25-75 m deep and Burns and Frost (1979) thought that 100 m was close to their maximum diving depth. In winter, some bearded seals do occur over waters 500 m or more in depth (Finley and Renaud 1980; C.R. Greene pers. comm.)

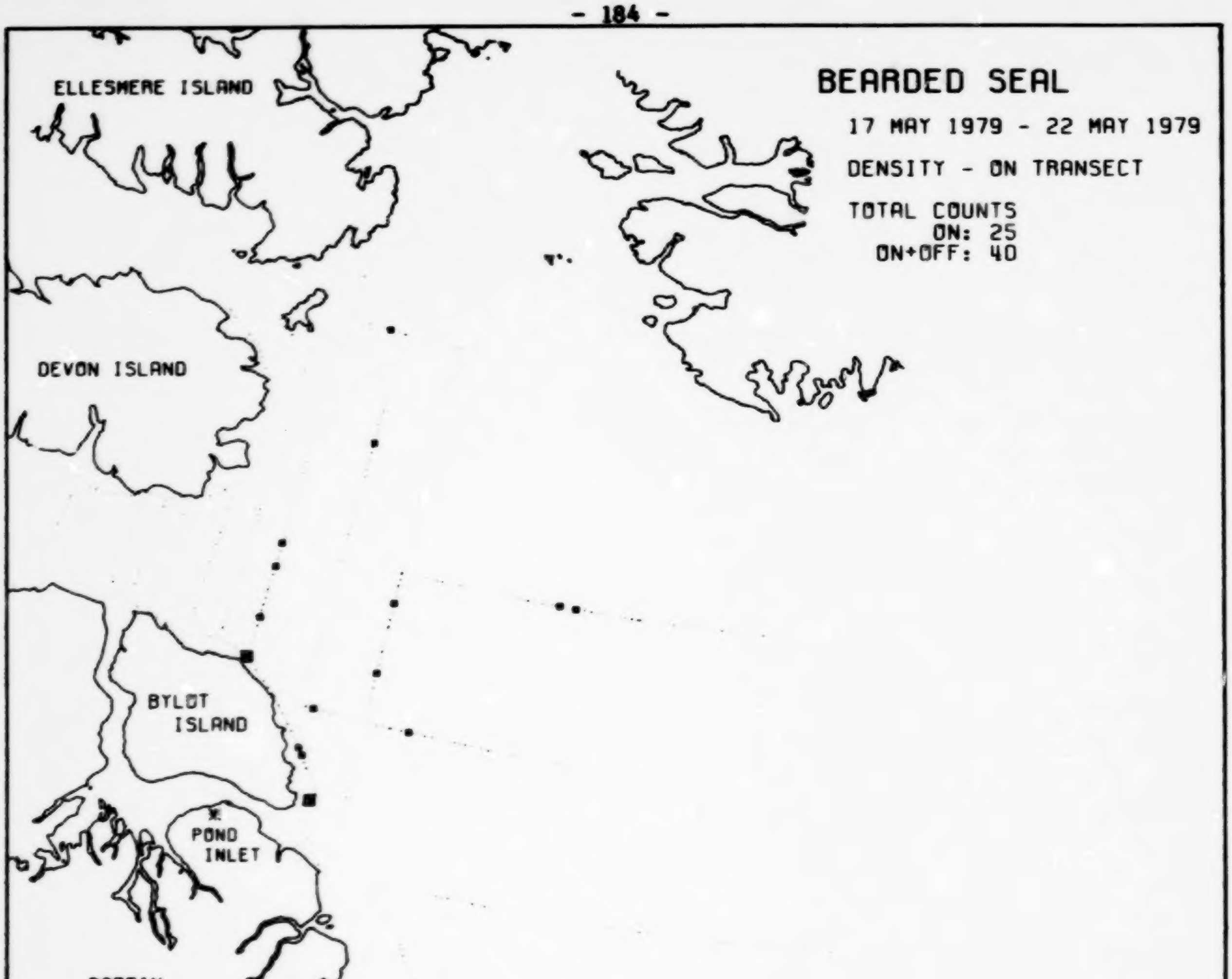

ELLESMERE ISLAND
BEARDED SEAL
17 MAY 1979 - 22 MAY 1979
DENSITY - ON TRANSECT
TOTAL COUNTS
ON: 25
ON+OFF: 40
DEVON ISLAND
BYLOT ISLAND
POND INLET
BAFFIN ISLAND
CLYDE
INDIVIDUALS/SQ.KM
2.6 - 5.0
1.6 - 2.5
1.1 - 1.5
0.6 - 1.0
0.1 - 0.5

FIG. 2.8.15 Bearded seal distribution in the study area, 17-22 May 1979. Densities shown are for four-min (≃12 km) transect segments. From Koski (1980a).

2.8.8 Polar Bear

The polar bear (Ursus maritimus) is circumpolar in distribution. It occurs throughout the eastern Lancaster Sound-western Baffin Bay area. The most recent estimate of the subpopulation in eastern Lancaster Sound is 1031 ± SD 236 animals (Schweinsburg et al. 1980).

Polar bears are present in the region during the winter but there are few data to describe their distribution. P.H.R. Stepney (in Schweinsburg et al. 1980) reported polar bears along both coasts and the eastern floe edge of Lancaster Sound in March. Hunters from Pond Inlet report the north coast of Bylot Island to be an important wintering area (R. Hawkins, pers. comm. in Schweinsburg et al. 1980). Apart from females in maternity dens, most bears are probably on the ice during the winter in search of their primary prey, the ringed seal. Knowledge of locations of maternity dens in the study area is incomplete but known denning areas include the east and north coasts of Bylot Island and the Croker Bay area on Devon Island (Schweinsburg et al. 1980). There are no areas, however, where polar bear dens have been found to be common. Stirling et al. (1977b) suggest that there is a large amount of suitable denning habitat in the arctic islands; thus, dens can be widely distributed.

During the spring and early summer, polar bears occur throughout the study area, both on landfast ice and on the offshore pack ice in Lancaster Sound and Baffin Bay. During aerial surveys from early May to mid-July in 1978 and 1979, the frequency of polar bear sightings was 3.3 and 5.5 bears/1000 km of survey, respectively. Bears were seen from Ellesmere Island south to Clyde River, Baffin Island (Koski and Davis 1979; Koski 1980a). Although polar bears are widespread at this time, they are not evenly dispersed. The coasts and ice edges of Lancaster Sound and east Devon Island had consistently higher frequencies of polar bear sightings (average of 31 bears/1000 km) than did other coasts and ice edges (average of six bears/1000 km). The frequency of sightings along the fast ice edge across Lancaster Sound averaged 40.1 bears/1000 km of survey during surveys from 17 May-1 July 1979. The overall frequency of sightings offshore in 1979 (4.1 bears/1000 km) was lower than that along coasts and ice edges (10.4 bears/1000 km) (Koski 1980a). However, because of the large amount of offshore habitat, total numbers offshore may be much higher than those along coasts and ice edges.

As the pack ice melts, some bears move toward coasts and ice edges, and some move southward with the retreating pack ice. Thus the frequency of sightings in Baffin Bay decreased from 5.8 bears/1000 km on 12-15 May 1979 to 2.9 bears/1000 km on 28 June-2 July 1979 (Koski 1980a). Several of the offshore sightings were of female bears with cubs or yearlings (Fig. 2.8.16).

Polar bears also occur on the pack ice in eastern Lancaster Sound when this ice is present. Johnson et al. (1976b) observed bears throughout this area when pack ice was present in May and early June of 1976. In 1979, in contrast, polar bears were not seen in offshore Lancaster Sound until late June and early July (10 bears were seen offshore on 9-15 July 1979), when the fast ice began to break up and pack ice first started to appear. Many of these animals may have come from the shelf of fast ice along Devon Island which broke up at the same time.

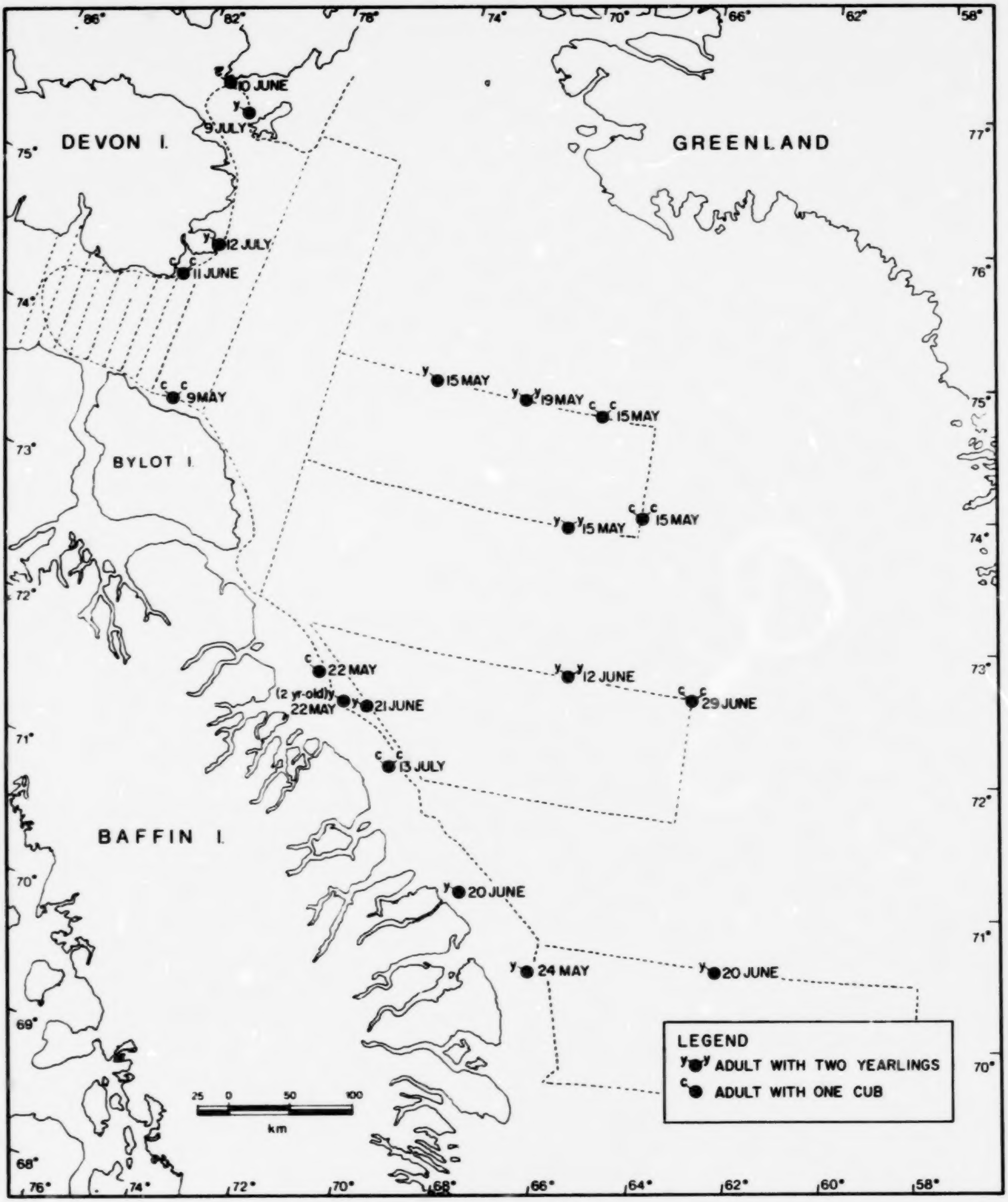

DEVON I.
GREENLAND
BYLOT I.
BAFFIN I.
10 JUNE
9 JULY
12 JULY
11 JUNE
9 MAY
15 MAY
19 MAY
15 MAY
15 MAY
15 MAY
22 MAY
(2 yr-old) 22 MAY
21 JUNE
12 JUNE
29 JUNE
13 JULY
20 JUNE
24 MAY
20 JUNE
LEGEND
ADULT WITH TWO YEARLINGS
ADULT WITH ONE CUB
25 0 50 100
km
86° 82° 78° 74° 70° 66° 62° 58°
76° 74° 72° 70° 68° 66° 64° 62° 60° 58°
77° 76° 75° 74° 73° 72° 71° 70°
75° 74° 73° 72° 71° 70° 69° 68°

FIG. 2.8.16 Sightings of polar bear adults with young in the study area, 9 May-15 July 1979. From Koski (1980a).

During the summer, when the seas are free of ice, polar bears are found in deep bays where landlocked ice remains until August or September. Such areas include Croker Bay and the mouth of Navy Board Inlet (Johnson et al. 1976b), and fiords along Baffin Island. For example, five bears were seen in Scott Inlet and Coutts Inlet on 10-14 September 1978 (Koski and Davis 1979).

Polar bears move to land after ice disappears in these bays and fiords, and these summer retreats are occupied until new ice forms in the fall. Within the study area, land areas where bears have been seen or are suspected to occur at this time include the south and east coasts of Devon Island, the perimeter of Bylot Island and the coast of Baffin Island (Schweinsburg et al. 1980). Surveys in 1978 and 1979 did not include land areas and provide little information about summer retreats. Schweinsburg et al. (1977) found that females with cubs and young bears of both sexes used the coastal summer retreats. Adult males tend to be more wide-ranging, with some moving inland and others remaining on floating pack ice. An example of the latter was a sighting of an individual on a small pan 135 km northeast of Buchan Gulf, off Baffin Island, on 30 August 1978 (Koski and Davis 1979).

There is little information about polar bear distribution in fall when they re-occupy the newly forming ice; however, sightings of four bears 15-40 km offshore in Baffin Bay on 10 October 1978 may have represented the beginning of a movement to offshore areas. One of these sightings included a female with one young (Koski and Davis 1979).

The polar bears in the eastern Lancaster Sound-western Baffin Bay area are all part of a population that includes bears in the central arctic at least as far west as west Barrow Strait (Schweinsburg et al. 1980). These bears are hunted on an annual quota basis by people in Resolute (1979 quota of 34 bears), Arctic Bay (12 bears), Pond Inlet (13 bears), Grise Fiord (33 bears) and Clyde (42 bears) (Schweinsburg et al. 1980).

2.8.9 Other species

Killer whale (Orcinus orca). -- Small numbers of killer whales move into the eastern Lancaster Sound-western Baffin Bay area during the open water period. Several sightings of this species were recorded during studies in 1978 and 1979. A group of seven-nine animals was seen off the mouth of Pond Inlet on 17 August 1978 and two sightings, each of two animals, were made in northeast Lancaster Sound on 22 August and 21 September 1978 (Koski and Davis 1979). Although killer whales were not seen during systematic aerial surveys in 1979, a group of 15 animals was seen chasing 400-500 narwhals and harp seals at the mouth of Navy Board Inlet on 23 September 1979 (I. Stirling, in Koski and Davis 1980). RRCS (1977) observed two killer whales in eastern Lancaster Sound in October 1975.

Killer whales probably remain in northern areas until forced south by formation of pack ice.

Hooded Seal (Cystophora cristata). -- Western Atlantic hooded seals whelp and breed in March on ice floes off northern Newfoundland and southern Labrador and in Davis Strait (Sergeant 1976b). Most migrate north to west Greenland and thence to Denmark Strait to moult, but small numbers reach the eastern Lancaster Sound-western Baffin Bay area in summer. Their routes into

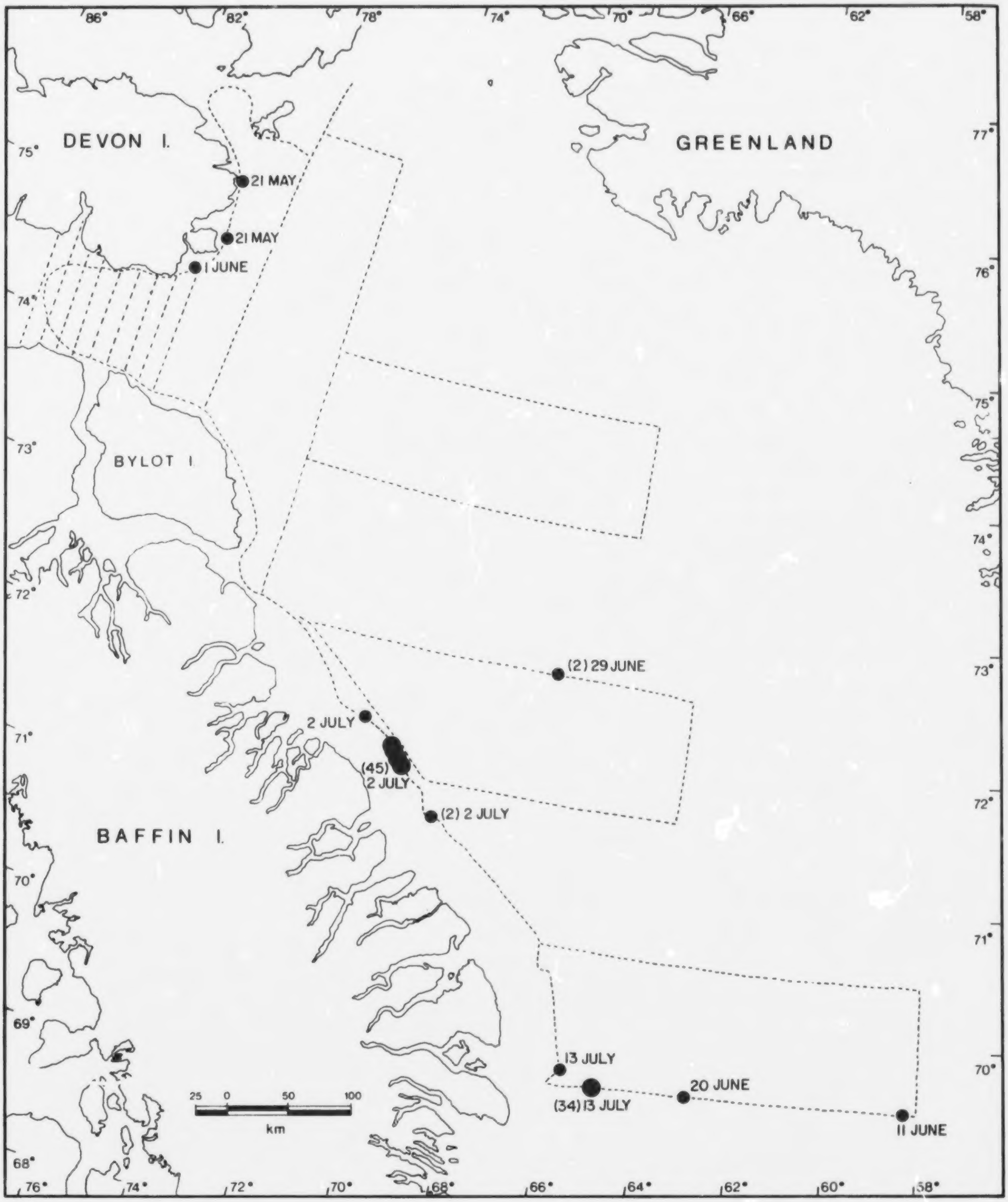

DEVON I.
GREENLAND
BYLOT I.
BAFFIN I.
21 MAY
21 MAY
1 JUNE
(2) 29 JUNE
2 JULY
(45) 2 JULY
(2) 2 JULY
13 JULY
(34) 13 JULY
20 JUNE
11 JUNE
25 0 50 100
km
86°
82°
78°
74°
70°
66°
62°
58°
77°
76°
75°
74°
73°
72°
71°
70°
69°
68°
76°
74°
72°
70°
68°
66°
64°
62°
60°
58°

FIG. 2.8.17 Hooded seal sightings in the study area, 9 May-15 July 1979. From Koski (1980a).

(and out of) the area are unknown. Koski and Davis (1979) recorded 19 individuals during surveys between 1 July and 10 October 1978; most were seen offshore in Baffin Bay and eastern Lancaster Sound, but one was identified along the northeast coast of Devon Island. In 1979, 90 animals were seen during surveys from 21 May to 13 July, primarily in southern and west-central Baffin Bay (Fig. 2.8.17), and generally hauled out on ice pans. Thirteen individuals were also seen on ice pans in eastern Lancaster Sound during surveys on 5 October (11 animals) and 16 October (two animals) 1979 (Koski 1980b).

Harbour Seal (*Phoca vitulina*). -- The harbour seal occurs in coastal areas throughout much of Canada (Mansfield 1967). Its status along the coast of Baffin Island is not well known; it has been taken at Arctic Bay and Pond Inlet (Mansfield 1967). Bissett (1967) states that the harbour seal is known in the Pond Inlet area, but not in large numbers. No harbour seals were recorded during the aerial surveys in 1978 and 1979. Similarly, none were identified during the surveys in 1976 (Johnson *et al*. 1976b, RRCS 1977).

Arctic Fox (*Alopex lagopus*). -- The arctic fox is basically a land mammal throughout its range, but some individuals venture onto sea ice to scavenge at the remains of seals killed by polar bears (Degerbøl and Freuchen 1935; Stirling and Smith 1977). Smith (1976b) considers arctic foxes to be important predators of ringed seal pups. No studies of the use of sea ice by arctic foxes in the eastern Lancaster Sound-western Baffin Bay area have been conducted. McLaren and Davis (1981), however, noted arctic fox tracks on offshore pack ice in southern Baffin Bay in March 1981.

3.0 HABITAT USE BY MARINE BIRDS AND MAMMALS

The seasonal distributions, movements and relative numbers of birds and marine mammals in the eastern Lancaster Sound-western Baffin Bay area were outlined in Sections 2.7 and 2.8. This section assesses the relative importances of various general habitat types, and the amount of ice cover in those habitats, to the various species. General habitats include coasts and ice-edges, glacier fronts and offshore waters. The information is based on results of aerial surveys conducted in the area from May to October 1978 (Koski and Davis 1979; McLaren and Renaud 1979) and May to July 1979 (Koski 1980a; McLaren 1980). Many of the data have been published in Bradstreet (1982a), McLaren (1982), McLaren and McLaren (1982), McLaren and Renaud (1982), Renaud and McLaren (1982) and Renaud et al. (1982).

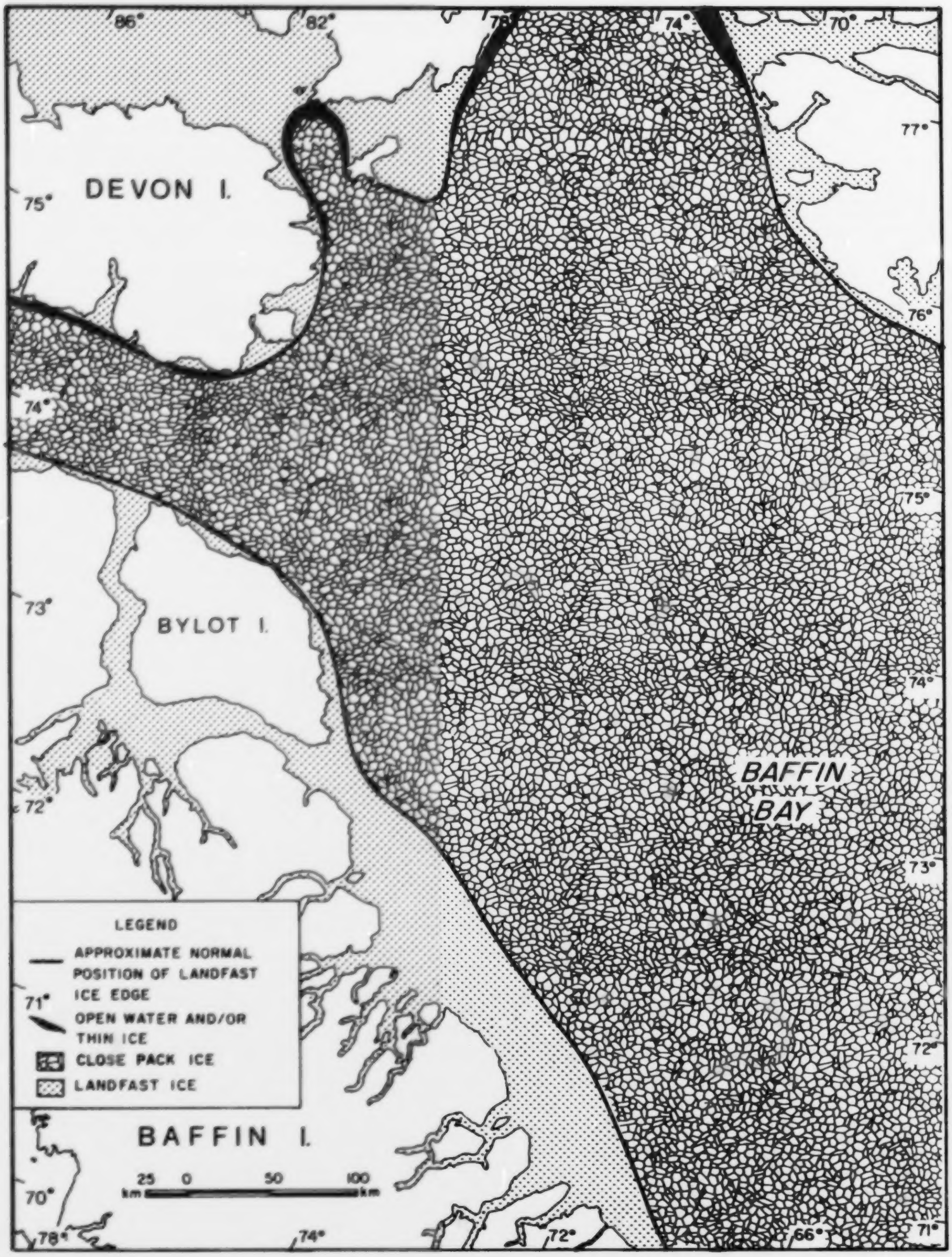
Most species of marine mammals and birds rely upon open water for feeding and/or resting. Thus the annual patterns of break up and movement of ice directly affect the movements and distributions of these species. These patterns have been generally reviewed in Section 2.1. The chronology of ice break-up in the eastern Lancaster Sound-western Baffin Bay area in 1978 and 1979 is reviewed below.

3.1. Chronology of Ice Break-up

During the winter and early spring, the offshore ice in Lancaster Sound and western Baffin Bay area is usually in intermittent restricted motion caused by winds, tides and currents (Canadian Hydrographic Service 1970). Landfast ice covers most bays and inlets along the coasts in the study area, and fast ice edges traditionally form across the mouths of Glacier Strait, Jones Sound, Navy Board Inlet and Pond Inlet (Fig. 3.1.1). These waterbodies are covered by landfast ice in winter and spring, and thus are inaccessible to birds and mammals that require open water. In 1978 and 1979, a fast ice edge also formed across eastern Lancaster Sound, with the result that fast ice covered all of the sound west of about Navy Board Inlet until mid-July. In most years, pack ice extends farther west through Lancaster Sound and eastern Barrow Strait.

As in most years, break-up of sea ice in 1978-1979 progressed from the north and northwest, with the result that the Coburg Island area and the entrance to Lancaster Sound were free of ice earlier than the rest of the area. The area of open water gradually expanded southeastward, although heavy pack ice remained in central and western Baffin Bay until August. By late May most coasts or shelves of coastal fast ice were bordered by well defined shoreleads. However, little or no open water was present along the fast ice edge along east Baffin Island until late June (Fig. 3.1.2).

Landfast ice persisted in bays and inlets until mid-July, but most such areas, as well as channels and fiords, were clear of ice by mid-August. Lancaster Sound was essentially free of ice by this time. The drifting pack ice in Baffin Bay continued to decrease in extent during July and had virtually disintegrated by early September. Offshore water remained largely ice-free through September, but bays and shallow inlets began to refreeze by late September. Extensive pack ice, which probably included multi-year ice from areas farther west, began to increase in northwest Baffin Bay by mid-October, when surveys terminated.


86°
82°
78°
74°
70°
77°
DEVON I.
75°
76°
74°
75°
73°
BYLOT I.
74°
BAFFIN
BAY
72°
73°
LEGEND
APPROXIMATE NORMAL POSITION OF LANDFAST ICE EDGE
OPEN WATER AND/OR THIN ICE
CLOSE PACK ICE
LANDFAST ICE
71°
72°
BAFFIN I.
25 0 50 100
km km
70°
78°
74°
72°
66°
71°

3.1.1 Typical winter ice conditions in the eastern Lancaster Sound-western Baffin Bay area.

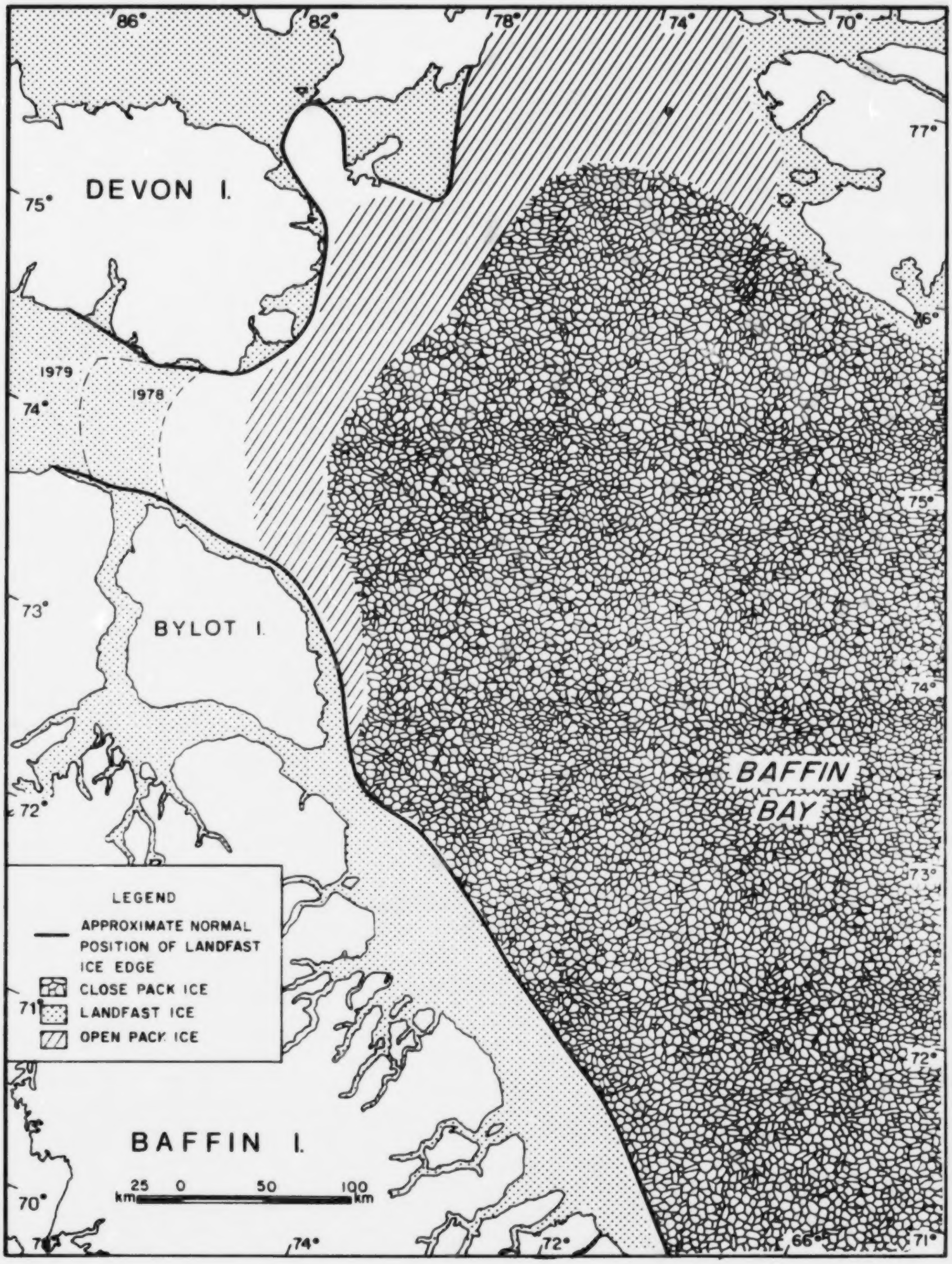

86°
82°
78°
74°
70°
77°
75°
DEVON I.
76°
1979
1978
74°
75°
73°
BYLOT I.
74°
72°
BAFFIN BAY
73°
LEGEND
APPROXIMATE NORMAL POSITION OF LANDFAST ICE EDGE
CLOSE PACK ICE
LANDFAST ICE
OPEN PACK ICE
71°
72°
BAFFIN I.
25 0 50 100
km km
70°
74°
72°
66°
71°

FIG. 3.1.2 Typical spring ice conditions in the eastern Lancaster Sound-western Baffin Bay area. Dashed lines in eastern Lancaster Sound depict positions of the fast ice edge in 1978 and 1979.

Plates 1-7 show the changing ice conditions in the eastern Lancaster Sound-Baffin Bay from early May to late August 1978.

3.2 Marine Birds

The following assessment of use of marine habitats by birds is based on the results of aerial surveys conducted in 1978 and 1979 (McLaren and Renaud 1979; McLaren 1980). Habitat use was evaluated from records of the habitat and the birds encountered in each two-minute segment of each transect. Each of these transect segments was about 6 km in length. The relative abundance of a species in several broad categories of habitat (fast ice edges, ice-free coastlines, glacier fronts, offshore areas) was evaluated initially, and then the relative abundance of the species in relation to the amount of pack ice present in each of those habitats was assessed. (Offshore areas were those at least seven km from the closest coast or fast ice edge.) These comparisons were done separately for different date ranges that corresponded to discrete phases of the nesting cycle. Detailed information about the seasonal distribution of each species appears in Section 2.7.

3.2.1 Coasts and Ice Edges

Figure 3.2.1 presents, for each of the major bird species, the densities recorded along interfaces (coasts, fast ice edges, glacier fronts), in relation to the amount of pack ice present along the interface. Oldsquaws, common eiders, and king eiders occurred in significantly higher densities along coasts than along fast ice edges, a reflection of the requirements of these species for shallow water feeding areas (Ellarson 1956; Palmer 1976). Glaucous gulls and kittiwakes also occurred in significantly higher densities along coasts. Northern fulmars occurred in generally similar densities along both ice-free coasts and fast ice edges; this is perhaps a reflection of the catholic food preferences of this species (Bradstreet 1976, 1980b). Thick-billed murres and black guillemots, on the other hand, occurred along ice edges in significantly higher densities than along ice-free coastlines. Bradstreet (1979a) also noted that these species prefer fast ice edges in the central part of the Canadian high arctic in 1976. For all those species, densities along interfaces tended to be highest in areas where there was little or no adjacent pack ice, although murres were common at sites where pack ice cover was as high as 90 percent. The preferences of all these species were generally similar throughout the spring and summer and did not change substantially during the various phases of the nesting cycle.

Dovekies, unlike the above species, were infrequent along ice edges and absent from ice-free coasts. They were much commoner in offshore areas (see below).

3.2.2 Glacier Fronts

In August and September, concentrations of northern fulmars, black-legged kittiwakes, glaucous gulls, and to a lesser extent, ivory gulls appear at places where glaciers reach the sea ('glacier fronts'). Glacier fronts are situated along the southeast and east coasts of Devon Island and the southeast coast of Ellesmere Island. Information describing bird distribution along these coasts is presented in Section 2.7 (for details, see McLaren and Renaud [1982] and Renaud and McLaren [1982]). Densities of these

Table 3.2.1. Densities (no. birds/km^2) of major seabird species recorded along interfaces (coasts and fast ice edges) and in offshore areas during aerial surveys in 1978 and 1979. Densities shown are for both years combined.

		Phase of Nesting Cycle[1]		
Species	Area	Pre-laying	Incubation	Chick-rearing & Fledging
Northern fulmar	interfaces	5.4	11.6	18.7
	offshore	0.3	1.0	0.6
Black-legged kittiwake	interfaces	9.4	9.9	25.5
	offshore	0.4	1.2	0.5
Thick-billed murre	interfaces	35.3	18.4	1.1
	offshore	2.8	3.0	0.7
Dovekie	interfaces	3.8	5.0	0.1
	offshore	36.2	7.4	0.5
Black guillemot	interfaces	2.8	1.0	0.1
	offshore	0.3	0.1	0.1

[1] See Figs. 3.2.1 and 3.2.2 for date ranges.

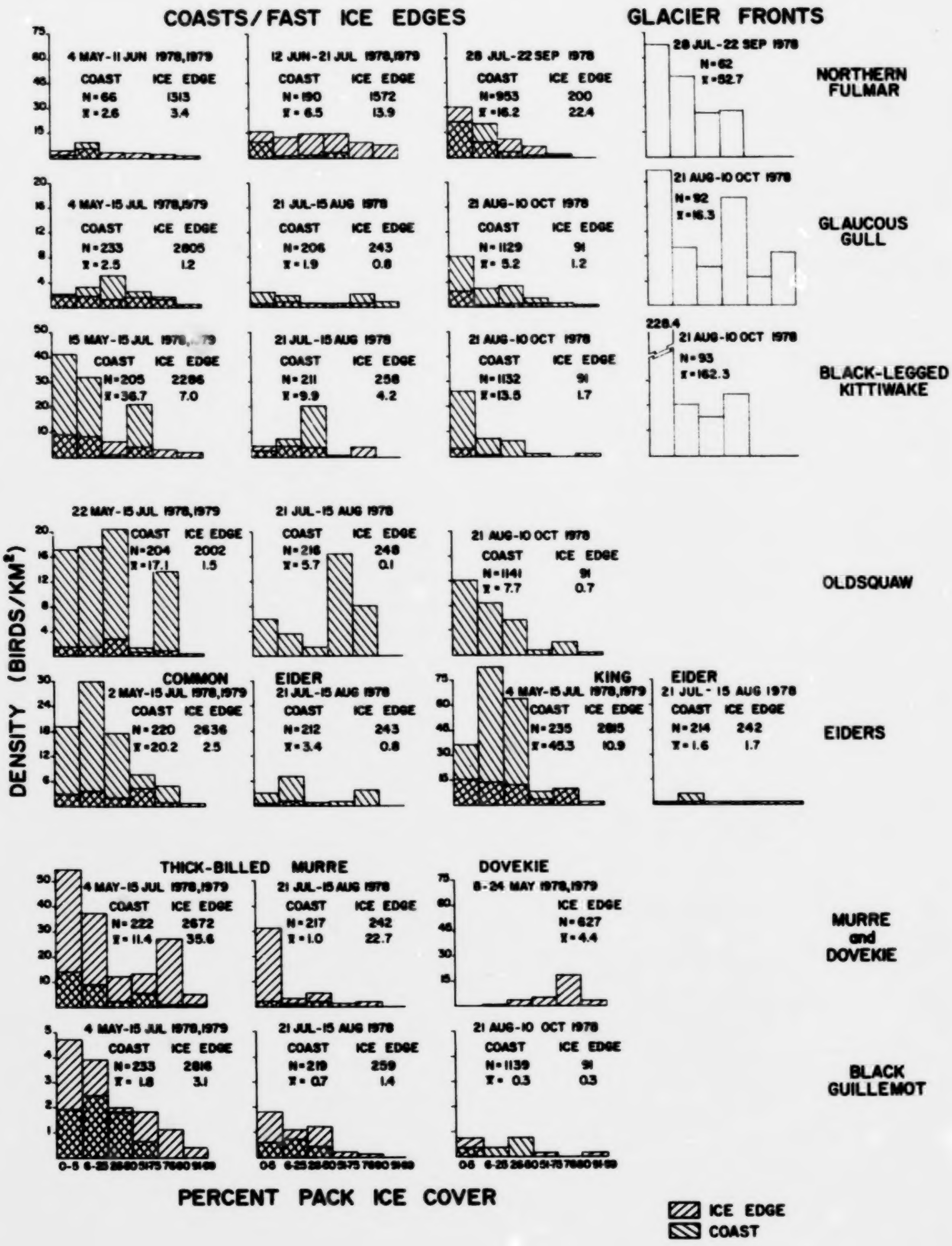


FIG. 3.2.1 Densities (no. birds/km^2) of seabirds along coasts, fast ice edges and glacier fronts in the study area, 1978 and 1979. Data from McLaren and Renaud (1979), McLaren (1980).

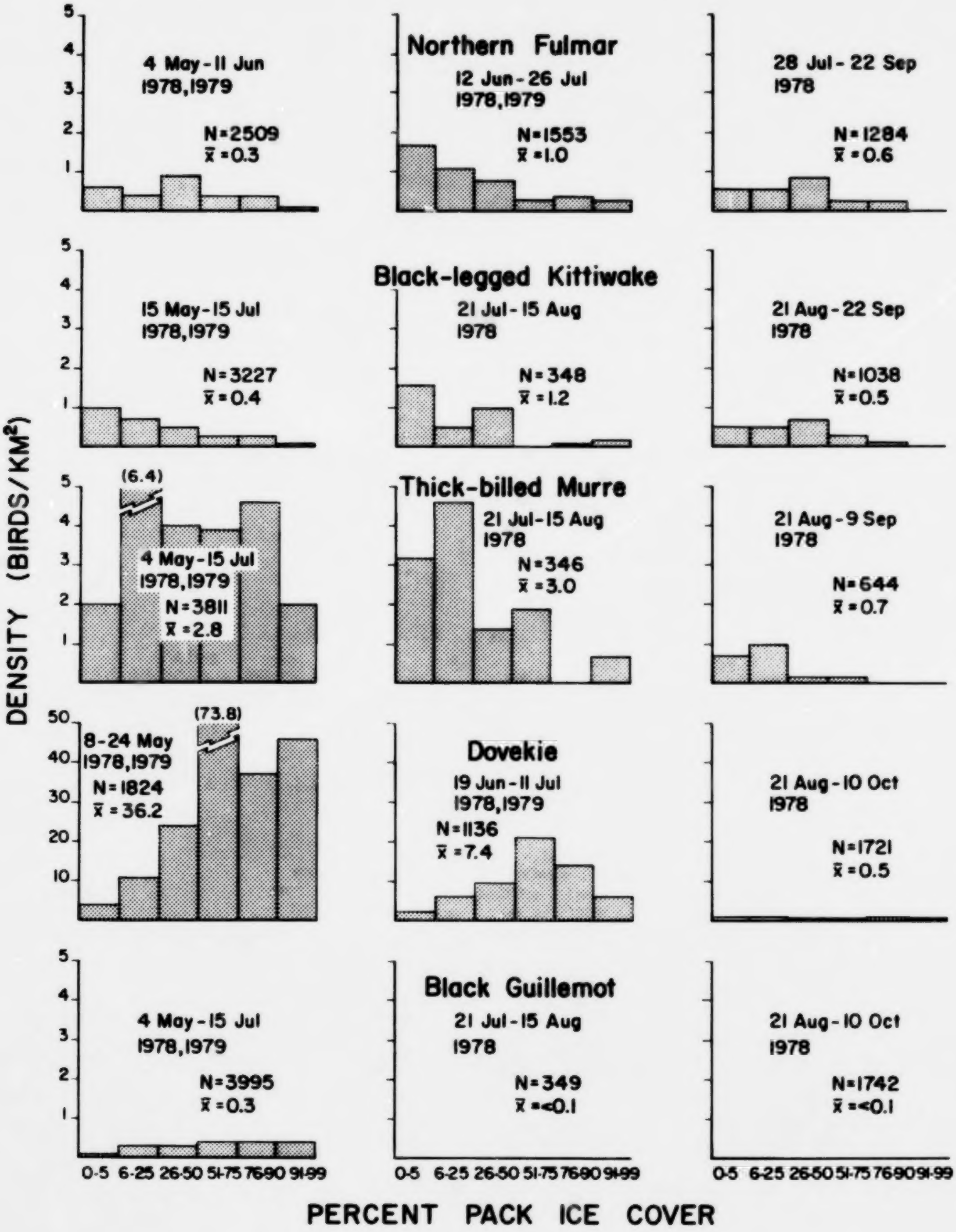


FIG. 3.2.2. Densities (no. birds/km^2) of seabirds in offshore areas of the study area, 1978 and 1979. Data from McLaren and Renaud (1979), McLaren (1980).

PLATES: ICE CONDITIONS IN NW BAFFIN BAY (NOAA IMAGERY)

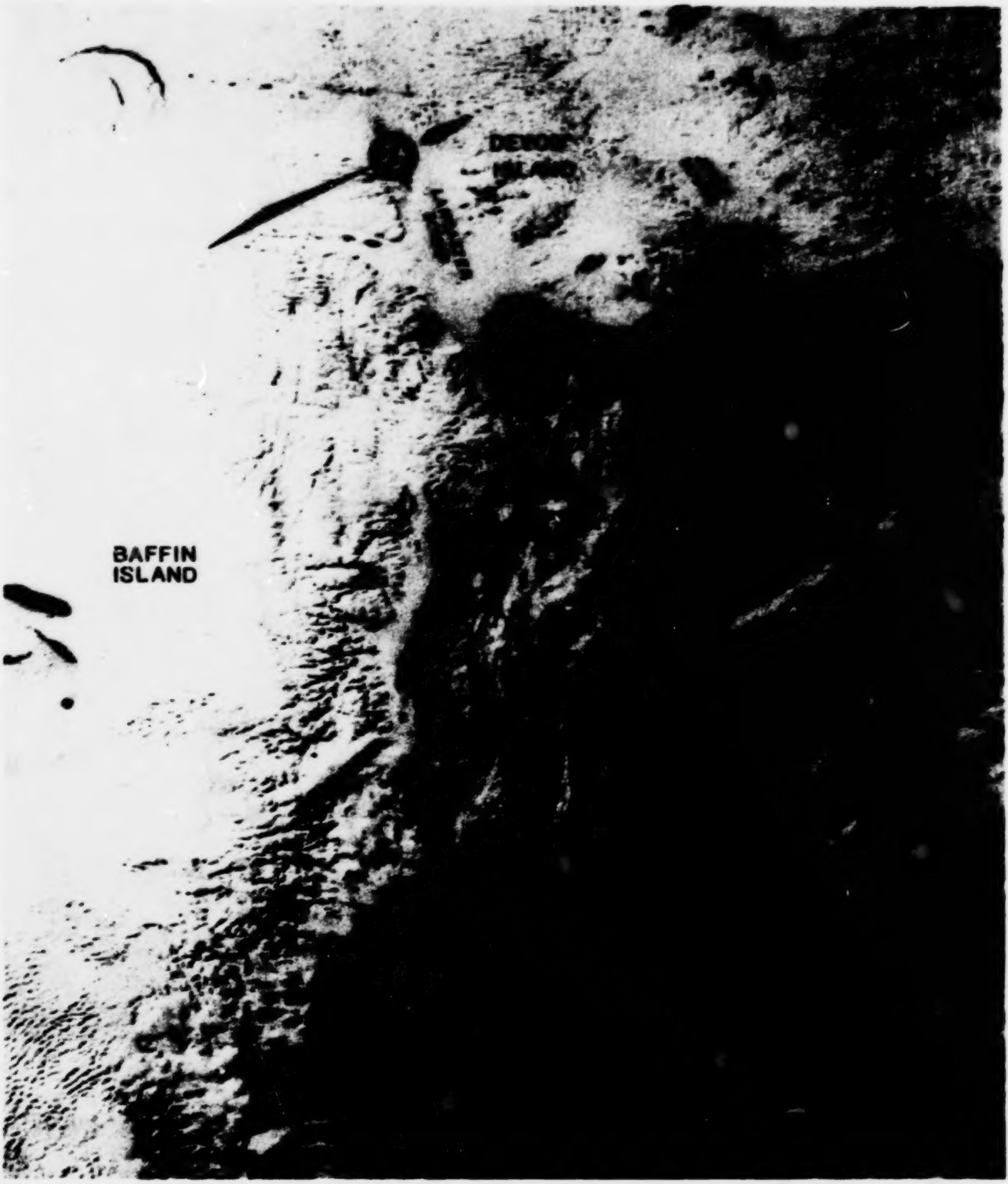

DEVON ISLAND
BAFFIN ISLAND

PLATE 1. ICE CONDITIONS IN NW BAFFIN BAY, 4 MAY 1978 (NOAA IMAGERY).

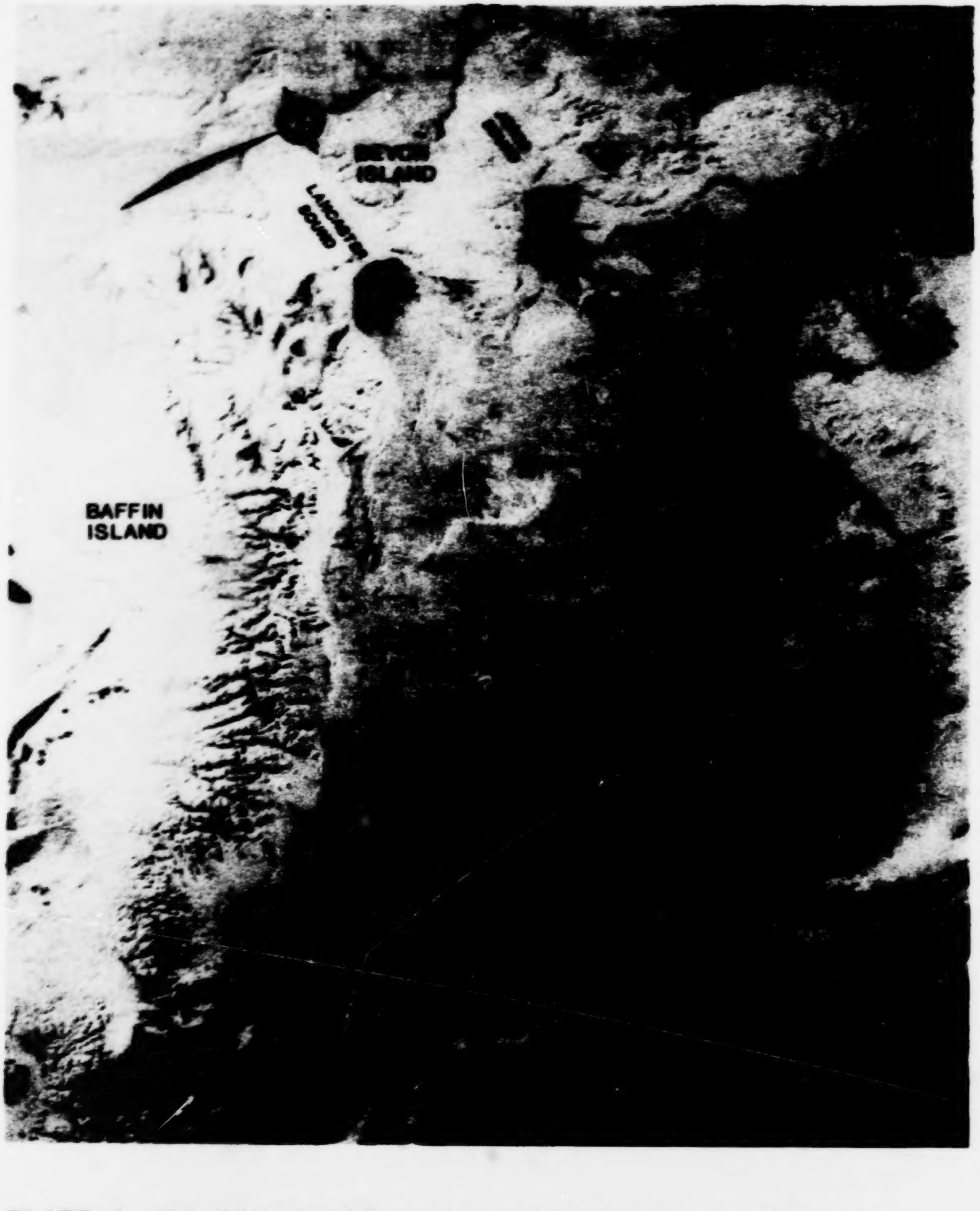

DEVON ISLAND
LANCASTER SOUND
BAFFIN ISLAND

PLATE 2. ICE CONDITIONS IN NW BAFFIN BAY, 21 MAY 1978 (NOAA IMAGERY).

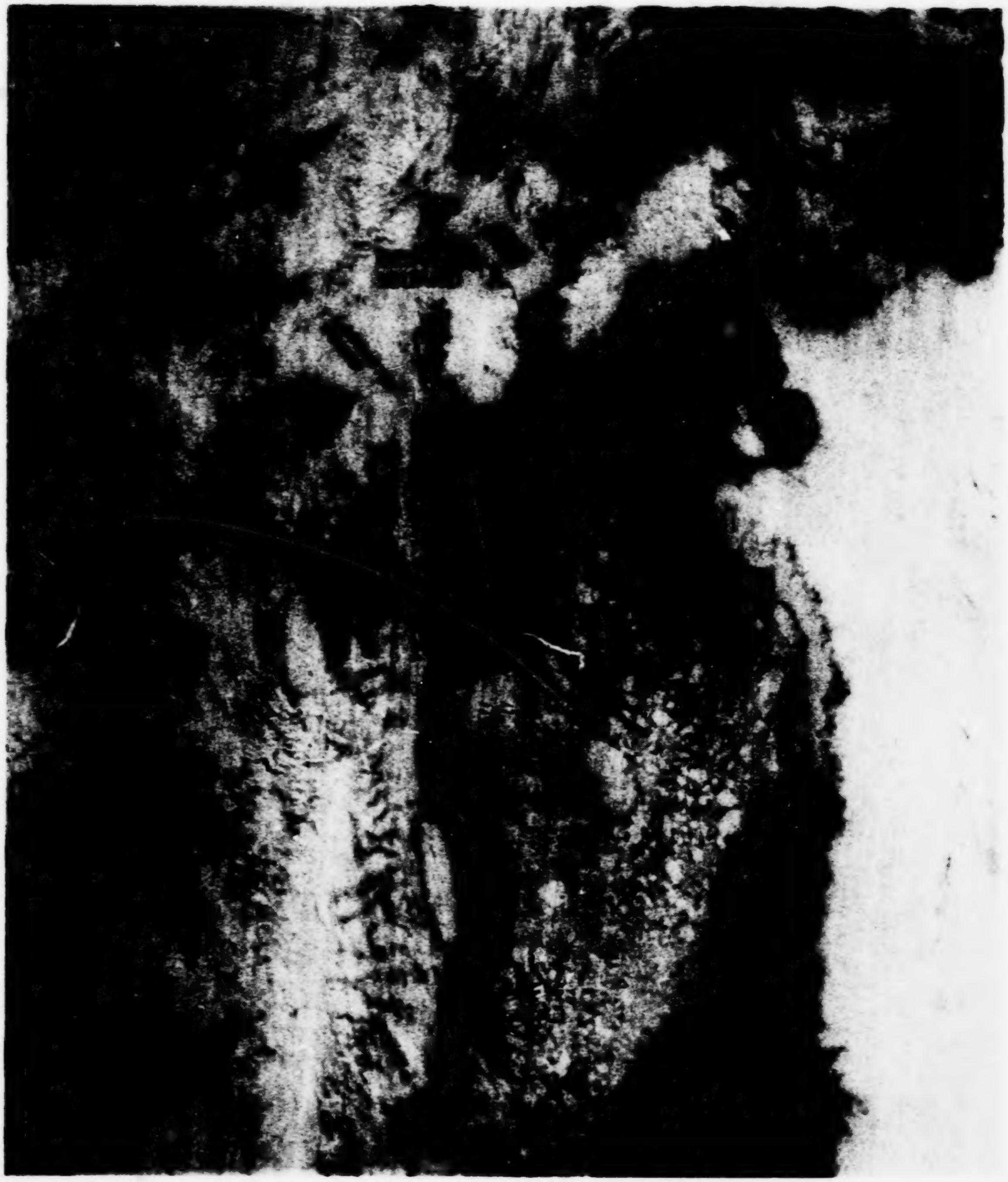


PLATE 3. ICE CONDITIONS IN NW BAFFIN BAY, 20 JUNE 1978 (NOAA IMAGERY).

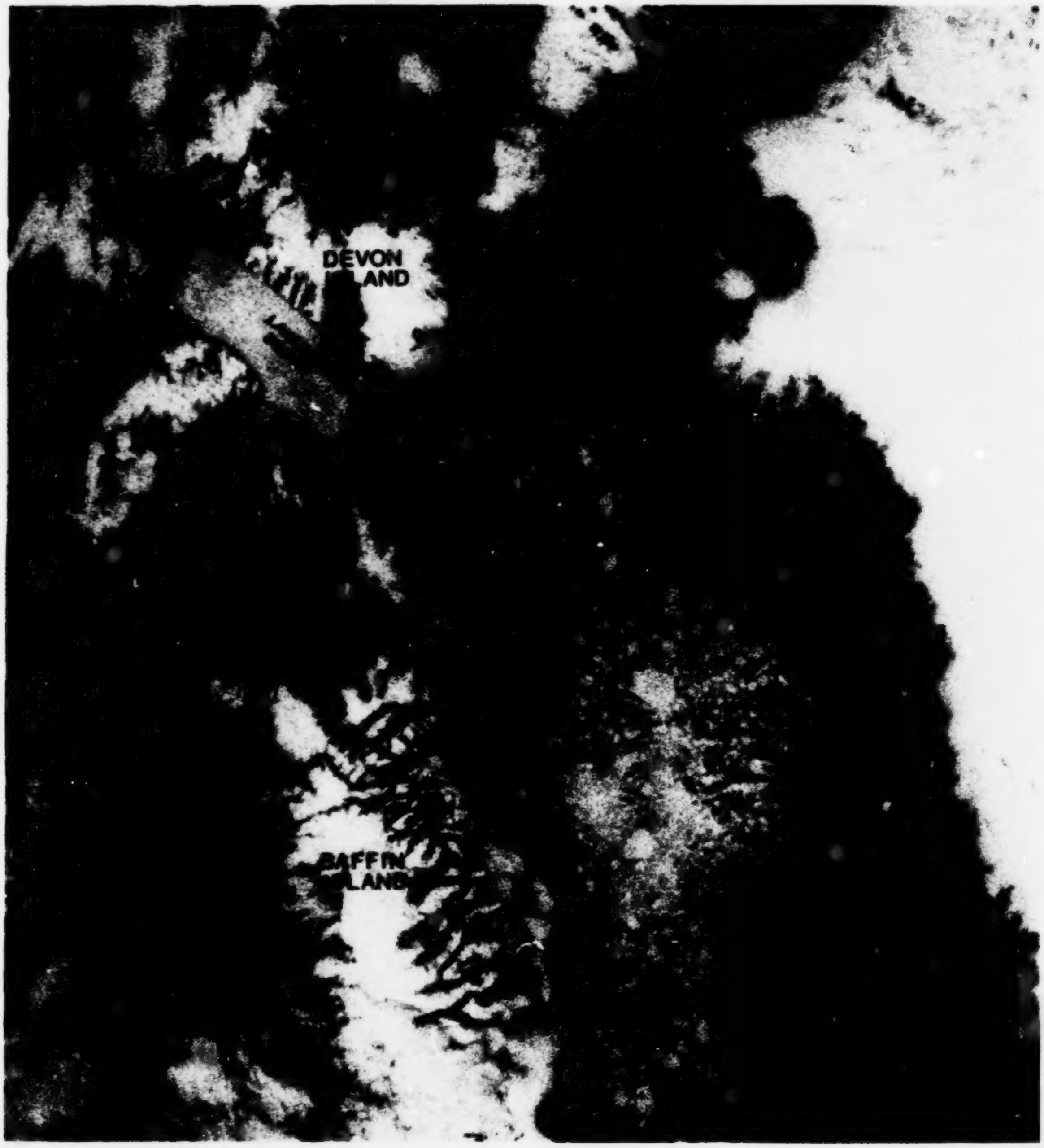

DEVON
ISLAND
BAFFIN
ISLAND

PLATE 4. ICE CONDITIONS IN NW BAFFIN BAY, 6 JULY 1978 (NOAA IMAGERY).

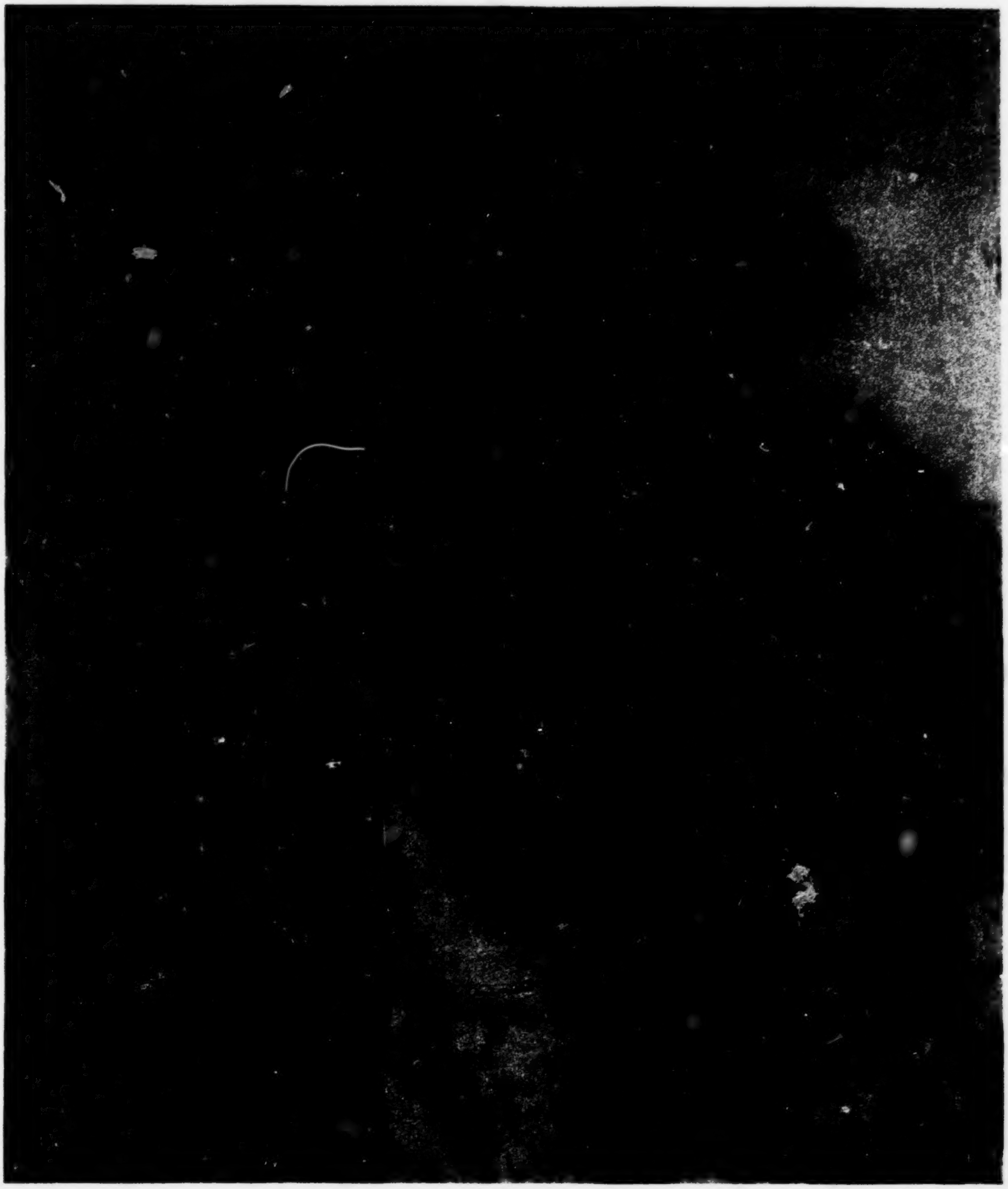


PLATE 5. ICE CONDITIONS IN NW BAFFIN BAY, 30 JULY 1978 (NOAA IMAGERY).

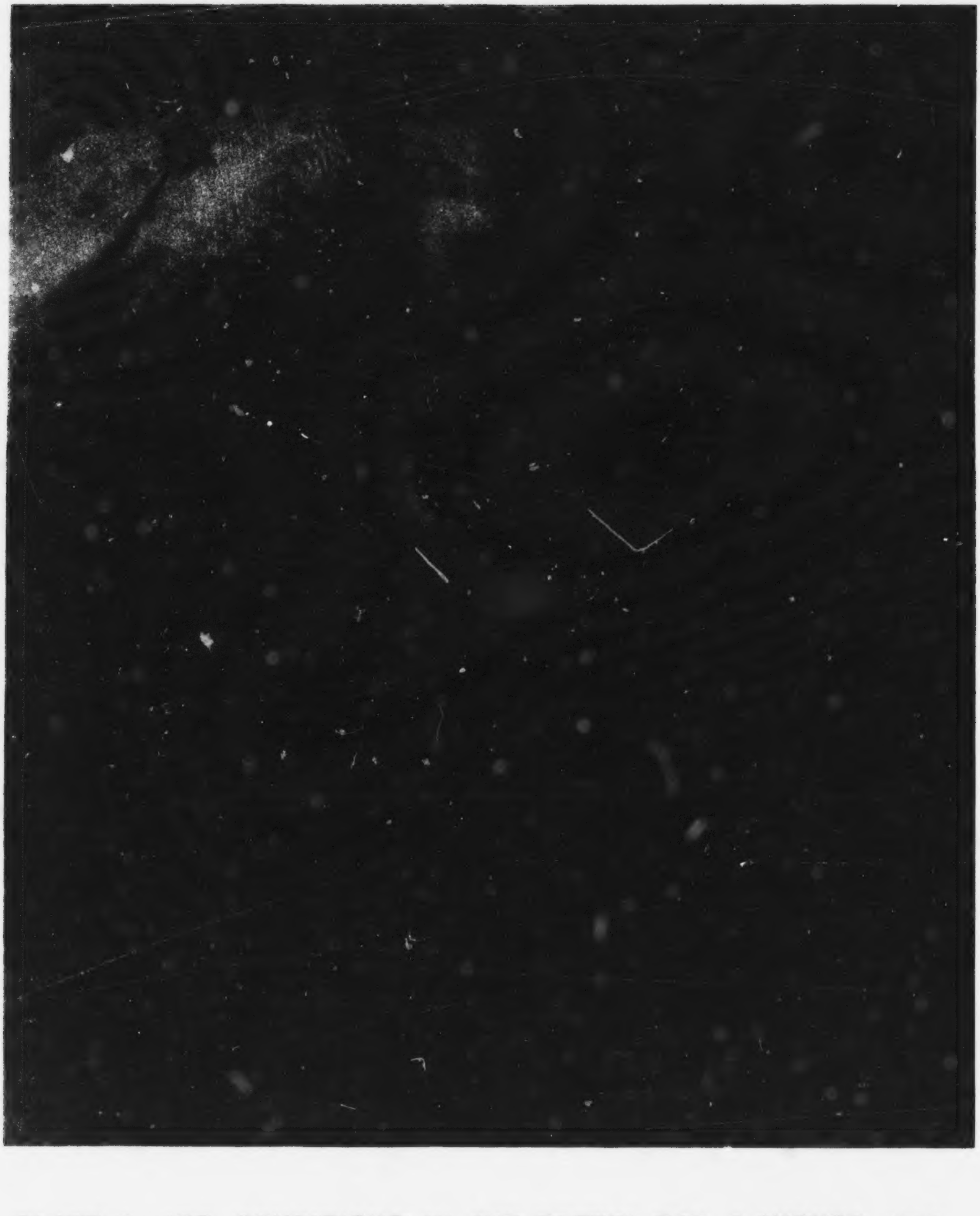


PLATE 6. ICE CONDITIONS IN NW BAFFIN BAY, 3 AUGUST 1978 (NOAA IMAGERY).

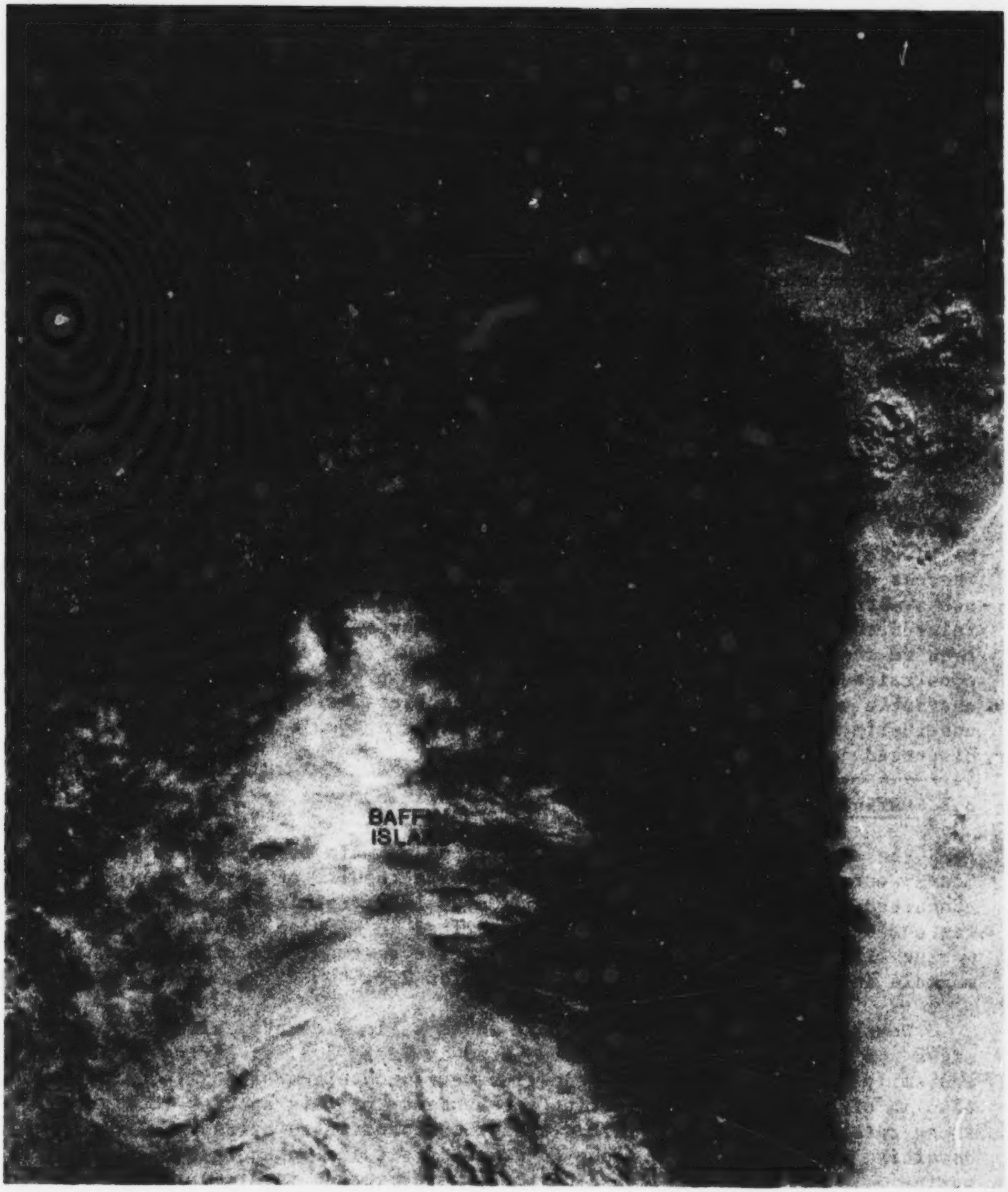

BAFFIN
ISLAND

PLATE 7. ICE CONDITIONS IN NW BAFFIN BAY, 20 AUGUST 1978 (NOAA IMAGERY).

species along glacier fronts are significantly higher than along adjacent coastlines (Fig. 3.2.1). Alcids (murres, guillemots) and waterfowl (oldsquaws, eiders), on the other hand, are not especially attracted to glacier fronts. Food habits of fulmars and gulls along these glacier fronts have not been studied, and thus the reasons for these concentrations are not known. However, it is probable that they occur in response to an abundant food source that is less numerous, or less accessible, elsewhere. The trophic processes in front of glaciers are discussed in Section 5.

3.2.3 Offshore Areas

Large numbers of birds migrate north through offshore areas in the spring (May-June). Species involved include the northern fulmar, red phalarope, Thayer's gull, ivory gull, black-legged kittiwake, thick-billed murre, dovekie and black guillemot. Although densities at this time are generally much higher along coasts and fast ice edges than in offshore areas (Table 3.2.1), total numbers offshore are often higher than along the interfaces, because of the much greater extent of offshore habitat. For dovekies, densities as well as total numbers are much higher offshore.

Figure 3.2.2 presents the densities of the major seabird species in offshore areas in relation to the amount of pack ice present. Fulmar and kittiwake densities tended to decrease with increasing pack ice cover, whereas densities of murres, dovekies and guillemots tended to be higher in areas with moderate to heavy pack ice. These relationships are probably related to feeding habits: fulmars and kittiwakes are surface feeders and require ice-free areas, whereas alcids dive for food and thus are not constrained to areas where ice is absent. The presence of ice makes available another class of foods--those associated with the ice undersurface. Trophic processes in pack ice and open water areas are discussed in Section 5.

3.3 Marine Mammals

The assessment of habitat use by marine mammals in the eastern Lancaster Sound-western Baffin Bay area is based on the results of aerial surveys conducted in 1978 and 1979 (Koski and Davis 1979; Koski 1980a). Habitat use was evaluated in the same manner as described in Section 3.2 for marine birds. Detailed information about the seasonal distribution of marine mammals in the area is presented in Section 2.8.

Densities recorded during aerial surveys along coasts, along fast ice edges and in offshore areas are presented in Table 3.3.1. During the spring and early summer, white whale densities were much higher along interfaces than in offshore areas, reflecting the tendency of this species to migrate along coasts and ice-edges rather than through offshore areas. Walrus densities were also higher along coasts and fast ice edges than offshore in spring. In May and early June, narwhals were present in similar densities along interfaces and offshore, but from mid-June on, densities were much higher along coasts and ice edges. Bearded seals were equally common in these two habitats during spring and early summer. Ringed seals occurred in significantly higher densities offshore than along ice edges and coasts, but this species also occurred at high densities on shelves of landfast ice along the coasts (see Section 2.8.6).

Table 3.3.1. Densities (no./km^2) of major marine mammal species recorded during aerial surveys in 1978 and 1979. (N) refers to number of transect segments (~six km of survey) from which densities were calculated. Data shown are for both years combined.

Species	Date	Density (N) Coasts & Ice Edges	Density (N) Offshore	P[1]
White Whale	May-mid July	3.38 (2618)	0.04 (3789)	<0.001
Narwhal	May-early June	0.21 (1303)	0.08 (2252)	NS
	early June-mid July	1.46 (1572)	0.13 (1925)	<0.001
	mid July-early Aug	3.54 (189)	0.04 (102)	<0.001
	Sept-Oct	0.83 (455)	0.20 (703)	<0.01
Walrus	May-mid July	0.21 (1509)	0.01 (3181)	<0.001
	mid July-mid Aug	0.27 (287)	0.04 (228)	<0.001
	mid Aug-Oct	0.07 (489)	<0.01 (730)	<0.001
Harp Seal	mid June-Oct	0.78 (2574)	0.08 (2972)	<0.001
Ringed Seal	late June	0.04 (1324)	0.45 (1776)	<0.001
Bearded Seal	May-mid July	0.02 (2210)	0.02 (3189)	NS
	mid Aug-mid Sept	0.11 (470)	<0.01 (789)	<0.001

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[1] Probabilities derived from chi-square contingency tests (see Koski and Davis (1979).

After the offshore pack ice dispersed in July and August, densities of all species were significantly higher along shorelines than offshore, although narwhals and harp seals still occurred regularly offshore. Ringed seals and bearded seals were rarely seen offshore in late summer. Bearded seals are bottom feeders that prefer shallow water.

During August and September, walruses and bearded seals often gather along glacier fronts. In September 1978, walrus densities were 0.20 walruses/km^2 along glacier fronts and 0.04/km^2 along adjacent coastlines; bearded seal densities were 0.85 and 0.03 seals/km^2 along glacier fronts and adjacent coastlines, respectively. Large numbers of white whales also lingered along glacier fronts during the eastward migration along southern Devon Island in 1978. Reasons for the presence of concentrations of marine mammals and seabirds (see Section 3.2) along glacier fronts are not known with certainty, but these concentrations presumably occur in response to a food source that is either less abundant or less accessible elsewhere. The trophic processes in front of glaciers are discussed in Section 5.

4.0 TROPHIC RELATIONSHIPS

The following material is an attempt to synthesize information, some of which is fragmentary, into a form that may be useful in determining the possible effects of exploration activities on food chains in eastern Lancaster Sound and western Baffin Bay. Several studies of the food habits of seabirds, marine mammals, arctic cod and organisms at lower trophic levels have been conducted in the study area. However, for some marine animals, area-specific information on food habits is fragmentary or absent. In such cases, the general results of other arctic studies can be used in suggesting important trophic relationships.

Many factors complicate interpretations of the trophic studies that have been conducted. Much existing information is qualitative (lists of species eaten) and yields little or no insight into the relative importance of various food species. Other studies report numbers of each species eaten, but not weight; and when weight is reported, it can be given as wet weight or dry weight. Although dry weight best approximates energy content of the diet, the actual caloric values of food species are seldom known. In addition, food requirements change depending on season and activities (e.g., egg-laying, rearing young, moulting, growth). Food availability and preferences also influence individual diets.

Below, the food habits of major groups of marine animals (marine mammals, marine birds, marine and anadromous fish, marine invertebrates) are presented. Then, the flow of energy from primary producers through various herbivore and carnivore pathways is traced.

In the following discussion, food taxa have, at times, been assigned to major groups on the basis of knowledge of their distribution and habitat preferences:

1. Zooplankton are animals that occur planktonically in the upper water layers and include, for example, Calanus spp. and Metridia spp. (copepods), Parathemisto spp. and Hyperia galba (amphipods), Pasiphaea spp. (decapods), Boreomysis spp. (mysids), Clione limacina and Limacina helicina (pteropod molluscs), and euphausiids.

2. Arctic cod are demersal, pelagic or ice-associated. Young-of-the-year arctic cod are pelagic (Sekerak 1982), but at about one year of age they become associated with a 'substrate'-- either the sea bottom or the undersurface of fast ice (Bain et al. 1977; Bradstreet 1980b). Given the importance of arctic cod to various seabirds and marine mammals, this species is considered separately from other fish.

3. Ice-associated amphipods--these animals are closely associated with fast ice or pan ice when it is present; when that ice melts, some of these species occur in the plankton, benthos, or both. Examples include Onisimus glacialis, Gammarus wilkitzkii, Gammaracanthus loricatus, Apherusa glacialis (MacGinitie 1955; Green and Steele 1975; Buchanan et al. 1977; Cross 1980, 1982).

4. Nearshore animals are primarily benthic species found in shallow coastal waters:

    a) crustaceans--these animals are benthonic during the open-water season; when ice cover is present, some may be ice-associated (Buchanan *et al*. 1977). Examples include *Onisimus litoralis*, *Anonyx* spp., *Gammarus setosus*, *Gammarellus homari*, *Mysis* spp., *Arcturus* spp., *Lebbeus* spp., and harpacticoid copepods.

    b) sculpins are cottid fish.

    c) molluscs include *Margarites* spp., *Mya truncata*, *Serripes groenlandicus*, etc.

5. Other animals include polychaetes, larval barnacles, squid, and rarely-detected amphipods (e.g., *Eusirus*, *Weyprechtia*, *Syrrhoe*, *Paroediceros*, *Ischyrocerus*).

4.1 Marine Mammals

Only a few quantitative studies of the diets of marine mammals in eastern Lancaster Sound and western Baffin Bay have been undertaken (Finley and Gibb in press; Bradstreet and Cross 1980; Finley and Gibb MS; Finley *et al.* in prep.). Davis *et al*. (1980) summarize important food chains involving marine mammals in the Arctic, and most of the following accounts are based on that review supplemented with more recent information. Because much of the available information is qualitative or from other arctic areas, the following accounts are sometimes speculative in nature.

4.1.1 Seals

Ringed, bearded, and harp seals occur commonly in eastern Lancaster Sound and western Baffin Bay. Hooded and harbour seals are uncommon and their diets are not discussed here.

Ringed seals primarily eat crustaceans, fish or both. McLaren (1958) reported that in shallow nearshore waters of southern Baffin Island, ringed seals fed chiefly on arctic cod, mysids and decapods, whereas in offshore waters, pelagic forms such as *Parathemisto* predominated in the diet. Similarly, Finley (1978) found that during June, ringed seals at Freemans Cove, Bathurst Island, fed largely on mysids, amphipods (*Parathemisto*, *Onisimus*) and arctic cod, with occasional sculpins, gastropods and decapods. Offshore in Barrow Strait during mid-winter and in Baffin Bay during June, ringed seals fed heavily on *Parathemisto* and pelagic cyclopterid fish (LGL Ltd. unpubl. data). In possible contrast to these results, Vibe (1950) in west Greenland, and Bradstreet and Cross (1980) in Pond Inlet, found arctic cod to be the principal prey of ringed seals foraging over deep but inshore waters. Vibe (1950) also noted (without details) that amphipods and decapods were the principal foods near coasts. In addition to taxa already listed, euphausiids, seasnails, squid and sculpins have also been reported as food items of ringed seals (Kumlien 1879; Dunbar 1949; Lowry *et al*. 1977, 1978a,b). After reviewing Alaskan and Soviet literature, Lowry *et al*. (1978b) concluded that ringed seal diets will consist of the most abundant and available species. In summary, in western Baffin Bay and adjacent waters, as elsewhere, arctic cod and Parathemisto libellula are often major components of the diet.

The **bearded seal** is primarily a benthic feeder with a diverse diet that apparently varies with age, location, water depth and time of year (Chapskii 1938; Kosygin 1971; Lowry et al. 1977, 1980). Food habits have been studied extensively in the Soviet Arctic and western Alaska, but there is very little information from Canada (Dunbar 1941c; Beaubier et al. 1970; Finley 1976). Major invertebrate foods include various gastropod and bivalve molluscs, crabs and shrimps. Other invertebrate foods include amphipods, isopods, cephalopods, holothuroideans, echiurids, sponges, priapulids and polychaetes (Chapskii 1938; Vibe 1950; Johnson et al. 1966; Burns 1967; Beaubier et al. 1970; Kosygin 1971; Finley 1976; Lowry et al. 1977, 1980). Arctic cod and various benthic fish (sculpins, eelpouts, seasnails, lumpsuckers, halibut) form variable portions of the diet (Chapskii 1938; Burns 1967; Lowry et al. 1980). Near Thule, Greenland, Vibe (1950) reported that bearded seals were normally omnivorous benthic feeders, but sometimes ate exclusively arctic cod when water depths exceeded 100 m, presumably because in such water depths, seals were unable to reach the bottom.

An analysis of 34 bearded seal stomachs taken in the study area showed that fish (all species) were the principal (85 percent) food items (Finley et al. in prep.). Arctic cod and sculpins each comprised 35 percent of the diet items. A large variety of benthic invertebrates were ingested by bearded seals but these were less than 15 percent of all food items and certainly much less in terms of diet energy. Gastropod snails, especially Buccinum sp., crangonid shrimps, especially Sclerocrangon boreas, and the bivalve Serripes groenlandicus comprised much of the invertebrate portion of the diet.

In southwest Greenland, **harp seals** feed heavily on capelin (Dunbar 1949; Sergeant 1973b) but farther north only arctic cod occurred in one stomach from northwest Greenland (Vibe 1980). In a small sample of harp seal stomachs (n=16) from the Canadian Arctic, Sergeant (1973b) found that arctic cod was the most frequent food item along with small pelagic crustaceans including mysids, euphausiids and amphipods. Recently, Finley and Gibb (in press) quantitatively studied the summer diet of harp seals in the Canadian Arctic. Sixty-three of 157 samples were analyzed in detail. Arctic cod accounted for 70 percent of the energetic content in the diet, and polar cod accounted for 30 percent. Although invertebrates comprised 8 percent of diet items, they comprised only 0.05 percent of diet energy. Seasnails, eelpouts, sculpins, halibut, Parathemisto, mysids, decapods and squid were also found in the samples. Most of the samples analyzed in detail were from adult (>five yr) seals. Young seals tend to summer in subarctic waters, where their diet may include considerable numbers of crustaceans (Sergeant 1973b).

4.1.2 Walrus

The walrus is a bottom feeder that concentrates on bivalve molluscs, especially Mya truncata and Serripes groenlandicus. Although clams form the bulk of walrus diet in both the Canadian Arctic and elsewhere, many other benthic organisms are taken including cephalopods, priapulids, holothuroideans, isopods, decapods, polychaetes and fish (Dunbar 1949; Vibe 1950; Buckley 1958; Mansfield 1958; Krylov 1971; Fay et al. 1977). Remains of seals (mostly ringed seals) and cetaceans have been found in walrus stomachs (Dunbar 1949; Loughrey 1959; Fay 1960) and occasionally, rogue male walruses may adopt a seal-feeding habit almost entirely (Fay 1960).

4.1.3 Whales

The **white whale** feeds on a wide variety of fish and invertebrates of pelagic and benthic origin. In arctic waters, arctic cod appear to be very important to white whales (Vibe 1950; Kleinenberg et al. 1964; Medvedev 1971; Finley 1976); Vibe (1950) also lists the Greenland halibut as an important food. Decapod crustaceans and squid are also taken over much of the range (Kleinenberg et al. 1964; Sergeant 1973b; Finley 1976). Although results from elsewhere indicate that diet varies with age and season, there are few relevant data from the Canadian arctic.

Arctic cod, polar cod, squid, decapod crustaceans and Greenland halibut are the usual items in the **narwhal** diet; several qualitative assessments list arctic cod as being the major diet component (Degerbøl and Freuchen 1935; Vibe 1950; Mansfield et al. 1975). A quantitative analysis of the stomach contents of 73 narwhals taken on Pond Inlet in 1978 and 1979 showed that arctic cod and Greenland halibut comprised 51 percent and 37 percent, respectively, of the total dietary energy (Finley and Gibb MS). In late summer in Eclipse Sound, few of the narwhals examined had food remains in their stomachs. In addition to the taxa listed above, sculpins, skates, and pleuronectid and other fish are also taken (Reeves and Tracey 1980; Finley and Gibb MS). Squid may be of more importance to narwhals during winter or early spring than they are during the summer period, when diet has been studied (Finley and Gibb MS).

The **bowhead** is a skimming-type baleen whale that is adapted to feed by straining small animals from large volumes of water (Nemoto 1970; Pivorunas 1979). In Davis Strait and Baffin Bay, Brown (1868) reported that zooplankton, mainly copepods and to a lesser extent pteropods, were important components of the diet. Elsewhere, copepods, mysids, euphausiids, hyperiid and gammarid amphipods, decapods, isopods, cumaceans and fish (arctic cod, sculpins and others) have been recorded (Johnson et al. 1966; Mitchell 1975; Lowry et al. 1978b; Lowry and Burns 1980). The presence of benthic animals in samples from several western arctic studies, along with recent behavioural observations (Wursig et al. 1982), suggests that bowheads sometimes feed on or near the bottom, at least in nearshore waters. However, zooplankton probably comprise most of the food (Griffiths and Buchanan 1982).

4.1.4 Polar Bear

In the Canadian high arctic, polar bears feed almost entirely on seals, primarily ringed seals, but also on bearded seals (Stirling 1974; Stirling and McEwan 1975; Stirling and Archibald 1977; Stirling and Latour 1978; Furnell and Oolooyuk 1980). Other marine mammals including belugas (Degerbøl and Freuchen 1935; Kleinenberg et al. 1964; Freeman 1973; Heyland and Hay 1976), walrus (Degerbøl and Freuchen 1935) and hooded seals (Stirling and Archibald 1977) are sometimes taken, but are probably of relatively limited importance to polar bears. During the summer, in areas where sea ice melts and some bears are stranded on land, diet is varied and includes birds, marine and land mammals, marine invertebrates, berries and other vegetation (Russell 1975).

4.2 Marine Birds

The feeding habits of five species of seabirds in western Baffin Bay and Lancaster Sound have been studied in some detail (Bradstreet 1976, 1977, 1978, 1979b, 1980a, 1982b; Nettleship 1977; Bradstreet and Cross 1980; Bradstreet et al. 1980; Gaston and Nettleship 1981). Most of these studies were based on the analysis of stomach contents, but some involved direct observations of adult birds returning to colonies with food for their chicks. Below, these studies have been organized to present diet information during different stages of the nesting cycle (arrival to hatching of eggs, chick-rearing, dispersal from colonies). The relative importance of various food taxa are assessed, where possible, on the basis of the estimated dry weights of the various food organisms at the time of ingestion as percentages of the total food ingested. Such estimates are the best available approximations of relative energetic inputs to the diet. At times, dry weight data unavailable; in such cases, presumed importance of various taxa were deduced from percent occurrence, percent abundance, or both. When data from more than one year are available, weighted averages were used as the best estimates of the importance of various taxa.

Several assumptions were made as to the biological significance of the occurrence of partially digested organisms in the stomachs examined. Two of these assumptions are especially important to the following interpretations:

1. The presence of squid (mostly Gonatus spp.) beaks was not used as an indication of recent ingestion of squid since these horny plates remain for long periods of time in bird stomachs (Clarke 196[illegible]

2. The presence of fish otoliths was assumed to indicate recent ingestion of whole fish (Uspenski 1956; Sanford and Harris 1967; K. Swennen, Netherlands Inst. for Sea Research, pers. comm.). However, some otoliths might remain for considerable periods of time in seabird stomachs with the result tha the relative importance of fish (with respect to other more quickly digested taxa) may be overestimated.

4.2.1 Arrival, Egg-laying and Incubation Period

Figure 4.2.1 shows the major trophic relationships of some seabird species occurring in Lancaster Sound and western Baffin Bay during the early portion of the nesting cycle. All birds but dovekies from 1979 were collected along ice edges either in Barrow Strait (1976) or Pond Inlet (1978, 1979). Dovekies collected in 1979 were taken in May from leads in floating pack ice about 80 km northeast of Bylot Island.

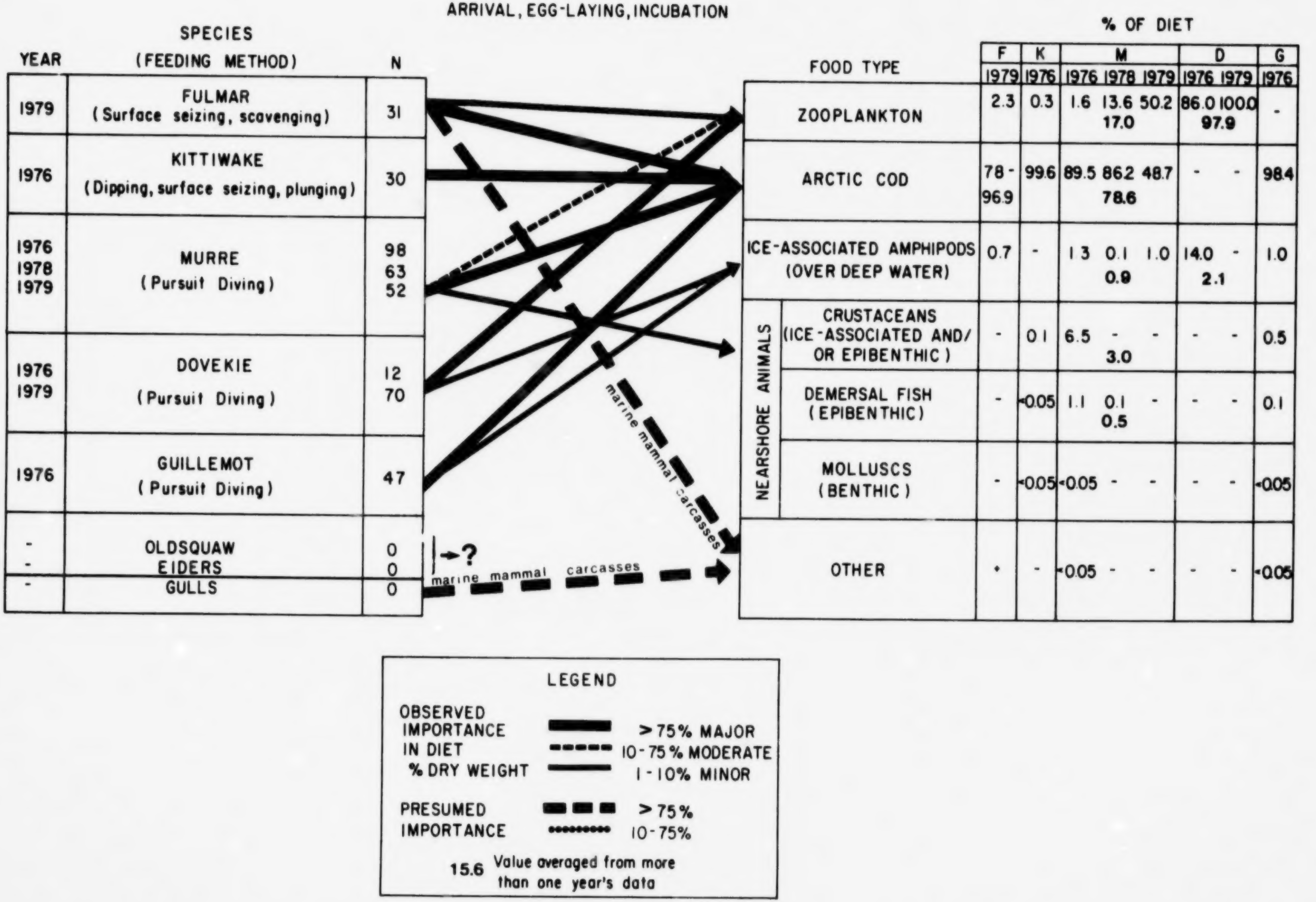
Arctic cod dominated the diets of all species except dovekies. Arctic cod ranged in importance from 78 percent (fulmars, murres) up to 99.6 percent (kittiwakes) of dry weight diet. Zooplankton were very important to dovekies (98 percent), moderately important to murres (17 percent), and unimportant to fulmars (two percent). Ice-associated amphipods were of minor importance to dovekies (two percent) and guillemots (one percent). Overall, nearshore animals were of minor importance to murres (four percent), although in 1976 murres collected along ice edges near coasts contained 26 percent nearshore animals. In 1979, fulmars at the Pond Inlet ice edge also fed on marine mammal carcasses left in or near the sea by Inuit hunters. Although it was not possible to incorporate such offal into the analytical methods used, Bradstreet and Cross (1980) concluded that offal was of major energetic importance in the diet of the collected fulmars.

Although fulmars, kittiwakes, murres and guillemots concentrated along ice edges, many more of these birds also occurred in much larger total numbers in the extensive offshore areas far from coasts and ice edges during the pre-hatching period. Nothing is known about the pelagic food habits of these species, nor about the food habits of other abundant species (eiders, oldsquaws) in the study area. Elsewhere, eiders and oldsquaws probably fed on benthic invertebrates in accessible shallow nearshore waters (Palmer 1976). Along ice edges, glaucous, Thayer's and ivory gulls fed extensively on marine mammal carcasses, but no systematic collections were made.

4.2.2 Chick-rearing Period

During the summer, adult fulmars, kittiwakes, murres, dovekies and guillemots were collected at sea while feeding for themselves or their chicks. In addition, adults carrying food for their chicks, or the chicks themselves, were collected at colonies in Lancaster and Jones sounds (fulmars, murres, guillemots) and in northwest Greenland (dovekies).

Figure 4.2.2 shows the diet of seabirds during the chick-rearing period. Many fulmars were collected at sea in 1976 and 1978; these birds comprised some unknown combination of active, failed or non-breeding adults, and sub-adults. The diet of these adult and sub-adult birds was diverse with zooplankton, arctic cod and nearshore animals each being of moderate (10-75 percent) importance in diet dry weight. By contrast, chicks at Prince Leopold Island were mainly fed arctic cod (D.N. Nettleship, CWS, pers. comm.). At sea, adult kittiwakes and murres fed mainly on arctic cod; zooplankton were of minor importance to each species. The diet of murre chicks at colonies was almost solely fish and almost totally arctic cod (Bradstreet 1978; Gaston and Nettleship 1981) although at Prince Leopold Island in 1975-1977 about 18 percent of diet items were sculpins. It seems probable that, whereas adult murres are obliged to feed their chicks fish, the adults are themselves foraging on invertebrates too, especially *Parathemisto* spp. (Bradstreet, pers. comm.). Although detailed analyses of the food of kittiwake chicks have not been published, Nettleship (1977) and Nettleship *et al.* (1979) note that, in addition to cod, kittiwake chicks at Prince Leopold Island were also fed zooplankton. Adult guillemots at sea fed mostly on arctic cod (84 percent of dry weight); zooplankton, ice-associated amphipods and benthonic crustaceans each formed minor components of adult diet. In 1977, guillemot chicks at Prince Leopold Island were fed numbers of benthonic fish and invertebrates as well as arctic cod (D.N. Nettleship, pers. comm.); each group is presumed to be of moderate importance in the diet of guillemot chicks. Zooplankton were of of major importance (83 percent) in the diet of dovekies chicks in northwest Greenland; ice-associated amphipods were of moderate importance (17 percent). At sea, adult dovekies fed mainly on zooplankton but to a moderate extent also on arctic cod (13 percent). Ice-associated amphipods were of minor importance in the diet of adult dovekies collected at sea.

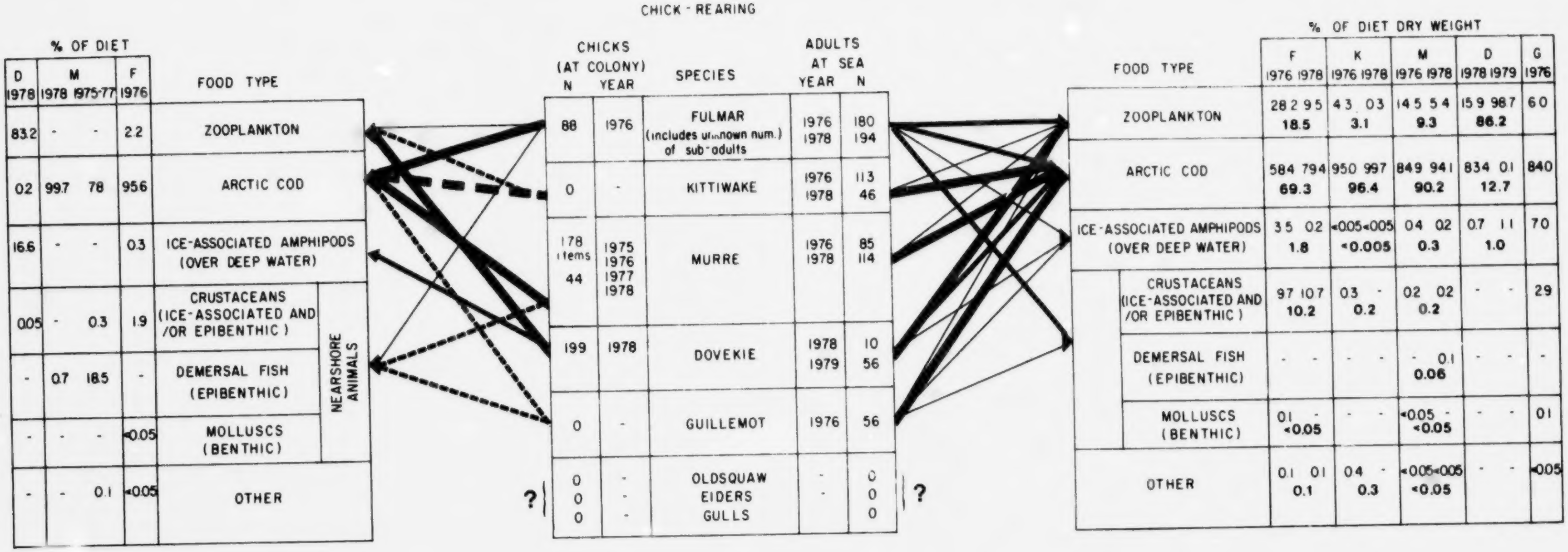

ARRIVAL, EGG-LAYING, INCUBATION
→?
marine mammal carcasses
marine mammal carcasses
LEGEND
OBSERVED IMPORTANCE IN DIET % DRY WEIGHT
>75% MAJOR
10-75% MODERATE
1-10% MINOR
PRESUMED IMPORTANCE
>75%
10-75%
15.6 Value averaged from more than one year's data

YEAR	SPECIES (FEEDING METHOD)	N
1979	FULMAR (Surface seizing, scavenging)	31
1976	KITTIWAKE (Dipping, surface seizing, plunging)	30
1976 1978 1979	MURRE (Pursuit Diving)	98 63 52
1976 1979	DOVEKIE (Pursuit Diving)	12 70
1976	GUILLEMOT (Pursuit Diving)	47
-	OLDSQUAW	0
-	EIDERS	0
-	GULLS	0

% OF DIET

	FOOD TYPE	F	K	M			D		G
		1979	1976	1976	1978	1979	1976	1979	1976
	ZOOPLANKTON	2.3	0.3	1.6	13.6 **17.0**	50.2	86.0 **97.9**	100.0	-
	ARCTIC COD	78 - 96.9	99.6	89.5	86.2 **78.6**	48.7	-	-	98.4
	ICE-ASSOCIATED AMPHIPODS (OVER DEEP WATER)	0.7	-	1.3	0.1 **0.9**	1.0	14.0 **2.1**	-	1.0
NEARSHORE ANIMALS	CRUSTACEANS (ICE-ASSOCIATED AND/ OR EPIBENTHIC)	-	0.1	6.5	- **3.0**	-	-	-	0.5
	DEMERSAL FISH (EPIBENTHIC)	-	<0.05	1.1	0.1 **0.5**	-	-	-	0.1
	MOLLUSCS (BENTHIC)	-	<0.05	<0.05	-	-	-	-	<0.05
	OTHER	+	-	<0.05	-	-	-	-	<0.05

FIG. 4.2.1. Major trophic relationships of some seabird species occurring in eastern Lancaster Sound and western Baffin Bay during the early portion of the nestin cycle. Data summarized from Bradstreet (1976, 1977, 1978, 1979b, 1980a); Bradstreet and Cross (1980); Bradstreet *et al*. (1980).



% OF DIET

D 1978	M 1978	M 1975-77	F 1976	FOOD TYPE	
83.2	-	-	2.2	ZOOPLANKTON	
02	99.7	78	95.6	ARCTIC COD	
16.6	-	-	0.3	ICE-ASSOCIATED AMPHIPODS (OVER DEEP WATER)	
0.05	-	0.3	1.9	CRUSTACEANS (ICE-ASSOCIATED AND /OR EPIBENTHIC)	NEARSHORE ANIMALS
-	0.7	18.5	-	DEMERSAL FISH (EPIBENTHIC)	
-	-	-	<0.05	MOLLUSCS (BENTHIC)	
-	-	0.1	<0.05	OTHER	

CHICKS (AT COLONY) N	CHICKS (AT COLONY) YEAR	SPECIES	ADULTS AT SEA YEAR	ADULTS AT SEA N
88	1976	FULMAR (includes unknown num.) of sub-adults	1976 1978	180 194
0	-	KITTIWAKE	1976 1978	113 46
178 items 44	1975 1976 1977 1978	MURRE	1976 1978	85 114
199	1978	DOVEKIE	1978 1979	10 56
0	-	GUILLEMOT	1976	56
0 0 0	- - -	OLDSQUAW EIDERS GULLS	- -	0 0 0

% OF DIET DRY WEIGHT

	FOOD TYPE	F 1976 1978	K 1976 1978	M 1976 1978	D 1978 1979	G 1976
	ZOOPLANKTON	28 2 9 5 **18.5**	4 3 0 3 **3.1**	14 5 5 4 **9.3**	15 9 98 7 **86.2**	6 0
	ARCTIC COD	58 4 79 4 **69.3**	95 0 99 7 **96.4**	84 9 94 1 **90.2**	83 4 0 1 **12.7**	84 0
	ICE-ASSOCIATED AMPHIPODS (OVER DEEP WATER)	3 5 0 2 **1.8**	<0 05 <0 05 **<0.005**	0 4 0 2 **0.3**	0 7 1 1 **1.0**	7 0
	CRUSTACEANS (ICE-ASSOCIATED AND /OR EPIBENTHIC)	9 7 10 7 **10.2**	0 3 - **0.2**	0 2 0 2 **0.2**	- -	2 9
	DEMERSAL FISH (EPIBENTHIC)	- -	- -	- 0 1 **0.06**	- -	-
	MOLLUSCS (BENTHIC)	0 1 - **<0.05**	- -	<0 05 - **<0.05**	- -	0 1
	OTHER	0 1 0 1 **0.1**	0 4 - **0.3**	<0 05 <0 05 **<0.05**	- -	<0 05

FIG. 4.2.2. Major trophic relationships of some seabird species occurring in eastern Lancaster Sound and western Baffin Bay during the chick-rearing period of the nesting cycle. Sources as in Fig. 4.2.1.

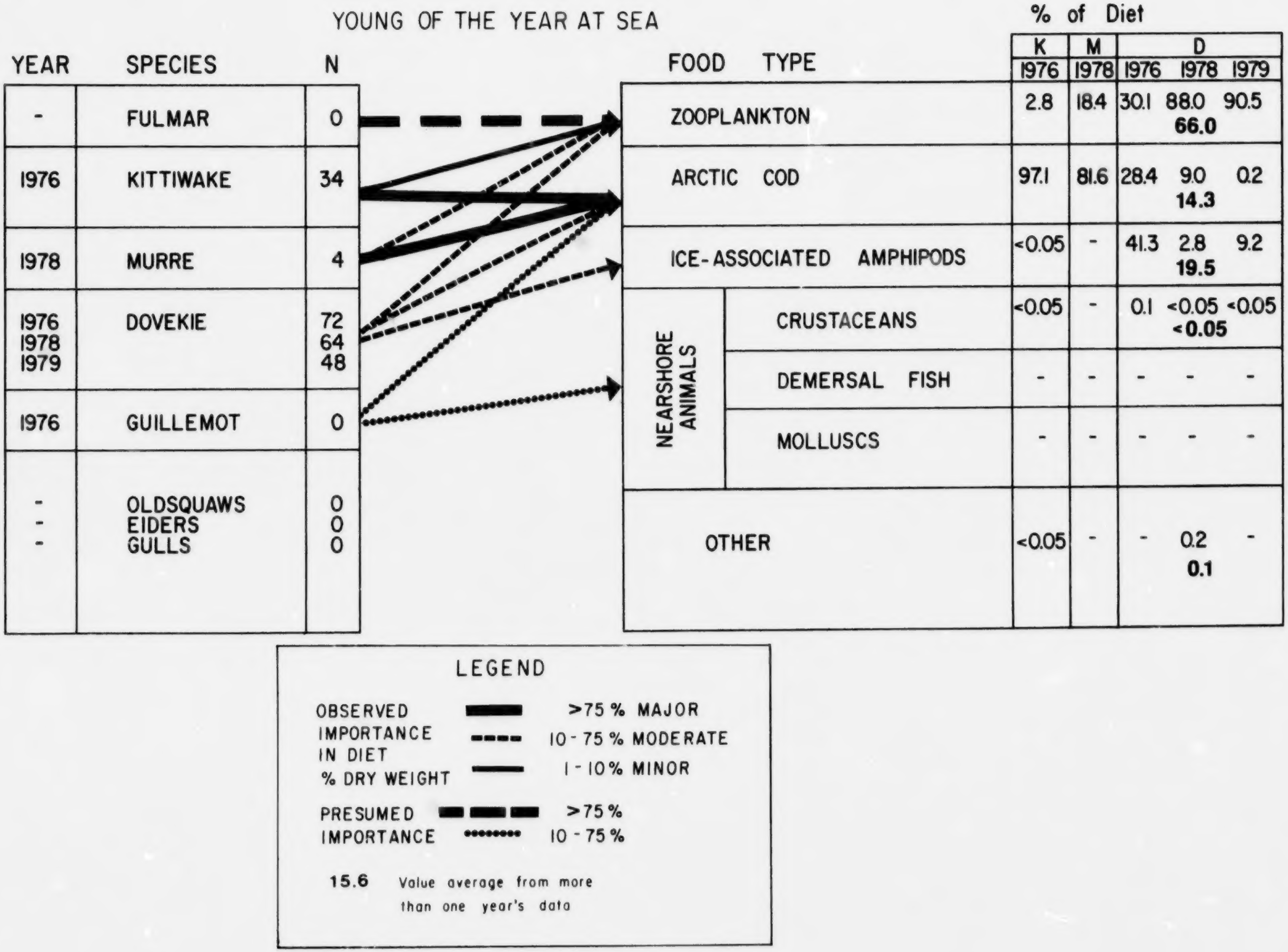

YOUNG OF THE YEAR AT SEA
YEAR
SPECIES
N
- FULMAR 0
1976 KITTIWAKE 34
1978 MURRE 4
1976 1978 1979 DOVEKIE 72 64 48
1976 GUILLEMOT 0
- - - OLDSQUAWS EIDERS GULLS 0 0 0
FOOD TYPE
ZOOPLANKTON
ARCTIC COD
ICE-ASSOCIATED AMPHIPODS
NEARSHORE ANIMALS
CRUSTACEANS
DEMERSAL FISH
MOLLUSCS
OTHER
% of Diet
K 1976
M 1978
D 1976 1978 1979
ZOOPLANKTON 2.8 18.4 30.1 88.0 90.5 66.0
ARCTIC COD 97.1 81.6 28.4 9.0 0.2 14.3
ICE-ASSOCIATED AMPHIPODS <0.05 - 41.3 2.8 9.2 19.5
CRUSTACEANS <0.05 - 0.1 <0.05 <0.05 <0.05
DEMERSAL FISH - - - - -
MOLLUSCS - - - - -
OTHER <0.05 - - 0.2 - 0.1
LEGEND
OBSERVED IMPORTANCE IN DIET % DRY WEIGHT
>75 % MAJOR
10 - 75 % MODERATE
1 - 10 % MINOR
PRESUMED IMPORTANCE
>75 %
10 - 75 %
15.6 Value average from more than one year's data

FIG. 4.2.3. Major trophic relationships of young seabirds occurring in eastern Lancaster Sound and western Baffin Bay after they have left the colonies. Sources as in Fig. 4.2.1.

4.2.3 Dispersal Period

Once fulmar, kittiwake, murre, dovekie and guillemot chicks leave their colonies, they quickly disperse at sea. Collections of young kittiwakes and a small number of murres suggest that cod are the major food items during dispersal (Fig. 4.2.3). Zooplankton were of minor importance to kittiwakes and moderate importance to murres. Young-of-the-year dovekies fed mostly on zooplankton (66 percent of dry weight), but cod (14 percent) and ice-associated amphipods (20 percent) were also important. No young fulmars or guillemots have been collected during the dispersal period; the importance of zooplankton to young fulmars and of arctic cod and nearshore animals to young guillemots have been presumed on the basis of adult and chick diets for each species.

4.3 Marine and Anadromous Fish

Most arctic fish are closely associated with the sea bottom and feed mainly on benthic and epibenthic animals. Only the pelagic arctic cod (*Boreogadus saida*) appears to feed extensively on zooplankton (see below). However, of all species cf marine fish in the Canadian high arctic, it is also the only one whose feeding habits have received more than cursory attention.

4.3.1 Arctic Cod

The feeding habits of arctic cod vary with age and habitat. Young-of-the-year arctic cod feed mainly on phytoplankton and to a lesser extent copepod nauplii (Bain *et al*. 1977). Larger arctic cod in nearshore waters feed mainly on amphipods and mysids, while those in offshore waters feed primarily on copepods (Bain and Sekerak 1978; Bradstreet and Cross 1980, 1982; Craig *et al*. 1982). There is some indication that larger fish tend to select larger prey than do smaller fish (Ponomarenko 1967; Bain and Sekerak 1978).

Arctic cod generally appear to feed on the most abundant organisms present. Bain and Sekerak (1978) found that the seasonal changes in the diet of arctic cod from Resolute Bay were commensurate with changes in the species composition of the zooplankton.

4.3.2 Other Marine Fish

Knowledge of the feeding habits of other marine species is at best rudimentary, and the little information that is available is not from the present study area. The information that is presented in the following discussion is from other arctic areas and, except where noted, is based on the work of Hildebrand (1948), Walters (1953), Andriashev (1954), Sekerak *et al*. (1976a) and Bain *et al.* (1977).

Amphipods appear to be the major food item consumed by sculpins (Cottidae). However, sculpins also feed on decapods, isopods, and (less frequently) on polychaetes and bivalves (op. cit. and Craig and Haldorson 1981). They will also feed on large zooplankters such as *Parathemisto libellula* and *Limacina helicina* when these are abundant. The feeding habits of eelpouts (Zoarcidae) are similar to those of sculpins in that benthic crustaceans, polychaetes and bivalves figure prominently in their diets.

Seasnails and lumpfish (Cyclopteridae) feed on benthic amphipods and mysids, but will also feed on planktonic animals. Blennies and gunnels (Pholidae) also feed on benthic crustaceans and polychaetes.

The Greenland shark (Somniosus microcephalus) is omnivorous and will feed on benthic animals, fish, offal from whale and seal hunting, and seaweed (Beck and Mansfield 1969). Greenland halibut (Reinhardtius hippoglossoides) feed mainly on fish, euphausiids and decapods (Lear 1970).

4.3.3 Arctic Char

Arctic char (Salvelinus alpinus) are anadromous fish that enter marine waters only in summer. They appear to remain in shallow nearshore waters within the marine areas where they occur. The food consumed by char in the marine environment consists primarily of epibenthic crustaceans, zooplankton and fish when available (Moore and Moore 1974; Sekerak et al. 1976a; Craig and Haldorson 1981).

In Creswell Bay, Somerset Island, Sekerak et al. (1976a) found that arctic char fed in waters less than 10 m deep and ventured into the intertidal zone at high water to feed on intertidal amphipods. They also found seasonal and areal differences in feeding habits. The appearance of large numbers of Parathemisto libellula and Limacina helicina in the plankton was reflected in the stomach contents of char. When pan ice drifted into the bay, large numbers of the ice-associated amphipod Apherusa glacialis were found in char stomachs. In some areas of Creswell Bay char fed primarily on mysids while in others they fed on plankton or nearshore amphipods.

4.4 Marine Invertebrates

4.4.1 Planktonic and Ice-associated Invertebrates

Bradstreet and Cross (1980, 1982) summarize current knowledge of the trophic relationships of underice invertebrates and present the results of work conducted in the study area. Underice amphipods appear to be important consumers of epontic algae. Onisimus glacialis and Apherusa glacialis fed solely on species of microalgae (Table 4.4.1). The species consumed were abundant and widespread on the undersurface of the ice. Buchanan et al. (1977) found that the young stages of Onisimus litoralis found under the ice also fed on ice-associated diatoms. Gammarus wilkitzkii feeds on epontic algae but also consumes crustaceans (Bradstreet and Cross 1980).

Copepods are the dominant zooplankters in the study area (Sekerak et al. 1979; Buchanan and Sekerak 1982). Most species are herbivorous and their mouth parts are well adapted to gnawing the hard frustules of diatoms (Anraku and Omuri 1963). Arctic copepods have made several adaptions to arctic conditions. For example, Calanus hyperboreus is able to build up large fat reserves during the relatively short period of phytoplankton abundance. Lee (1974) found that the lipid content of arctic specimens was higher (75 percent of dry wt) than that of temperate specimens (55 percent). When food is scarce, C. hyperboreus lowers its metabolic rate, ceases moulting, and survives on stored reserves (Conover 1962; Lee 1974). Some arctic copepods are able to breed in the absence of phytoplankton and the young stages that are produced may not feed for several months (Hansen et al. 1971). In this

Table 4.4.1. Diet of ice-associated amphipods along the Pond Inlet ice edge, 1979 (from Bradstreet and Cross 1980).

Food taxon	*Onisimus glacialis* No. stomachs (n = 10)	*Onisimus glacialis* Total importance[a]	*Apherusa glacialis* No. stomachs (n = 10)	*Apherusa glacialis* Total importance[a]	*Gammarus wilkitzkii* No. stomachs (n = 10)	*Gammarus wilkitzkii* Total importance[a]
Amphiprora spp.	4	5	-	-	-	-
Amphora spp.	7	8	2	2	-	-
Diploneis littoralis	1	1	-	-	-	-
Gomphonema exiguum	2	2	-	-	-	-
Licmophora spp.	2	2	-	-	3	3
Navicula directa	3	3	-	-	-	-
" *forcipata*	4	4	-	-	-	-
" *gelida*	3	4	-	-	-	-
" *quadripedis*	1	1	-	-	-	-
" *salinarum*	4	5	-	-	-	-
" *vanhoeffenii*	1	1	-	-	-	-
" spp.	7	13	6	6	5	6
Nitzschia angularis	8	13	-	-	-	-
" *cylindrus*	8	15	1	1	1	1
" *delicatissima*	8	12	-	-	1	1
" *distans*	1	1	-	-	-	-
" *frigida*	10	25	3	3	4	4
" *grunowii*	10	20	1	1	4	5
" *longissima*	9	10	-	-	1	1
" *seriata*	-	-	1	1	-	-
" *signa*	5	5	-	-	-	-
" spp.	3	5	8	9	2	2
Pinnularia quadrateria	3	4	-	-	-	-
" spp.	2	2	-	-	-	-
Pleurosigma angulatum	1	1	-	-	1	1
" *elongatum*	1	1	-	-	-	-
" spp.	7	7	-	-	-	-
Rhoicospheria curvata	1	1	-	-	-	-
Chaetoceros septentrionalis	2	2	-	-	1	1
" spp.	2	2	1	1	1	1
Filamentous alga	-	-	1	1	1	1
Microflagellates	-	-	4	5	3	3
Crustacean parts	-	-	-	-	5	5

[a] Food taxon abundance in each stomach ranked as follows: 1 = rare, 2 = few, 3 = common. Total importance is sum of abundance ranks in 10 stomachs.

Table 4.4.2. Percent occurrence of algae in the stomachs of calanoid copepods from Wellington Channel in June 1976 (from Bain *et al*. 1977).

Taxon	*Calanus hyperboreus* n = 27[a]	*Calanus glacialis* n = 30[b]	*Pseudocalanus* sp. n = 9[c]
Chaetoceros atlanticus	4	–	–
C. borealis	–	7	–
C. decipiens	4	13	–
C. socialis	4	–	–
All *Chaetoceros*	8	13	–
Coscinodiscus sp.	15	7	–
Diploneis sp.	4	–	–
Gomphonema sp.	11	–	–
Licmophora sp.	4	–	–
Melosira arctica	–	3	–
Navicula spp.	11	10	–
Nitzschia cylindrus	4	–	–
N. delicatissima	–	3	–
N. frigida	15	20	–
N. grunowii	78	87	78
N. longissima	4	–	–
N. seriata	48	64	44
All *Nitzschia*	96	100	100
Thalassiosira gravida	–	3	–
T. nordenskioeldii	7	10	11
All *Thalassiosira*	11	23	11
Unident. flagellates	15	–	–

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[a] The 27 samples consisted of 10 adult female, 9 stage V, and 8 stage IV copepod stomachs.

[b] The 30 samples consisted of 11 adult female, 10 stage V, and 9 stage IV copepod stomachs.

[c] The 9 samples each consisted of 5 adult females.

Table 4.4.3. Diet of Parathemisto spp. amphipods along the Wellington Channel ice edge in 1976 (Bain et al. 1977) and the Pond Inlet ice edge in 1978-79 (Bradstreet and Cross 1980).

Food taxon	1976	1978	1979[a]				All years ($\underline{n}$ = 27)
	From zooplankton (n = 9)	From murre stomachs (n = 8)	From murre stomachs (n = 5)		From zooplankton (n = 5)		
	No. stomachs	No. stomachs	No. stomachs	Total importance	No. stomachs	Total importance	% occurrence
Achnanthes taeniata	-	1	-	-	-	-	4
Amphora spp.	-	1	-	-	-	-	4
Melosira arctica	-	1	-	-	-	-	4
Navicula forcipata	-	-	1	1	-	-	4
N. salinarum	-	-	1	1	-	-	4
All Navicula	1	2	3	4	2	2	30
Nitzschia cylindrus	1	2	-	-	-	-	11
N. frigida	3	1	2	3	1	2	26
N. grunowii	8	3	2	2	4	4	70
N. longissima	-	-	1	1	-	-	4
N. seriata	5	1	-	-	-	-	22
All Nitzschia	9	5	5	10	4	9	85
Pleurosigma spp.	-	1	1	1	-	-	7
Crustacean parts	2	8	5	6	4	5	70

[a] In 1979, food taxon abundance in each stomach ranked as follows: 1 = rare, 2 = few, 3 = common. Total importance is sum of abundance ranks.

are able to take advantage of the entire period of phytoplankton productivity. In some areas, breeding is opportunistic and occurs only when food supply will permit (Cairns 1967).

The feeding habits of three of the most common calanoid copepods in the Lancaster Sound-western Baffin Bay region were studied in nearby Wellington Channel by Bain et al. (1977; Table 4.4.2). They concluded that these species were feeding on the most abundant phytoplankters found in the water column and that feeding was non-selective.

Hyperiid amphipods, ctenophores, medusae, chaetognaths and gymnosomatous pteropods are the most common predators in the zooplankton of the study area. The first three groups are major predators of herbivorous zooplankton and fish larvae. Although gelatinous forms (ctenophores, medusae) do not comprise a concentrated source of energy for higher trophic levels, they may, in the absence of other food, be taken by fish (Fraser 1962). Also ctenophores and medusae are extremely important components in the pelagic food web because they compete with other carnivores for herbivorous zooplankton. They may also have severe effects on populations of fish larvae, seriously affecting recruitment to adult fish populations (Fraser 1969).

Hyperiid amphipods, especially Parathemisto libellula, are probably the most important carnivorous zooplankters in the study area. P. libellula is very important in the transfer of energy from lower to higher trophic levels (Dunbar 1957; Bradstreet 1976, 1977, 1979b, 1980a). P. libellula feeds mainly on crustacean zooplankters and on phytoplankton (Table 4.4.3; Dunbar 1946; Wing 1976). Hyperiid amphipods are also important predators of fish larvae (von Westernhagen and Rosenthal 1976).

The gymnosomatous pteropod Clione limacina is rather unique among zooplankters, especially arctic forms. It feeds exclusively on the the cosomatous pteropod Limacina (Lalli 1970). In contrast, most other invertebrate carnivores in the Arctic are able to take advantage of whatever food is most abundant.

In summary, copepods are the dominant herbivores in the study area. Because of their small size, they usually are not consumed directly by seabirds and marine mammals (with the exception of bowhead whales, for which copepods are probably a major food item). Carnivorous invertebrates as well as arctic cod (see section 4.3.1) act as intermediaries in the transfer of food energy from herbivorous zooplankton to most birds and mammals.

4.4.2 Benthic Invertebrates

The ultimate source of the food consumed by benthic invertebrates is the primary productivity of the phytoplankton, macrophytic algae and benthic microalgae. Benthic animals living within the euphotic zone may utilize this food directly, but those at greater depths must receive it indirectly.

Most of the productivity of macrophytic algae enters the detritus food chain. In addition, phytoplankters that are not consumed, phytoplankters that are attacked but not eaten, as well as herbivore faeces may all sink to the sea bottom and become available for consumption by the benthos. In the

North Sea, Crisp (1975) has estimated that benthic animals consume an amount equivalent to 50 percent of the annual primary productivity of the phytoplankton. In most cases, this detritus is of little direct nutritional value to benthic animals. It does, however, form a nutritional substrate for the bacteria that are a primary source of food for benthic deposit feeders (Wildish 1977). Marshall (1970) has pointed out that many benthic filter feeders utilize food of benthonic as well as pelagic origin and thus compete with deposit feeders for the available organic matter.

4.4.2.1 Infauna

In Lancaster Sound and western Baffin Bay, Thomson and Cross (1980) found that shallow water infaunal communities were characterized by filter feeders and that deeper water communities were characterized by deposit feeding animals. A depth-related trend in feeding mode is also evident among polychaetes (Table 4.4.4).

The dominance of filter feeders at shallow depths and deposit feeders at deeper depths is well known (Jumars and Fauchald 1977). However, filter feeders are generally sessile and unable to cope with sediment instability due to wave action at the shallowest depths (Jumars and Fauchald 1977). Seventy-one per cent of the polychaetes found at the shallowest depths (10 m) were capable of movement (42 to 51 percent at other depths.)

Table 4.4.4. Feeding modes[1] of polychaetes found at four depth intervals in eastern Lancaster Sound and western Baffin Bay. Expressed as a percentage of biomass.

Depth (m)	No. Samples	Filter Feeders	Deposit Feeders	Predators And Scavengers
5-10	55	26.3%	62.9%	10.8%
15-52	55	47.0	34.3	18.7
53-250	44	10.4	71.1	18.5
250-1100	25	9.5	81.2	9.4

[1] Polychaetes classified according to Jumars and Fauchald (1977) using the collections of Thomson and Cross (1980).

In general, shallow depths (25 m) in the study area are characterized by filter feeding bivalves of the genera *Astarte*, *Serripes*, *Musculus* and *Hiatella*. At greater depths, the deposit feeding *Macoma calcarea* increases in density. It, in turn, gives way to deposit feeding echinoderms and polychaetes at depths greater than 100 m (Thomson and Cross 1980).

4.4.2.2 Epibenthic Animals

The amphipods *Gammarus setosus*, *Onisimus litoralis* and *O. glacialis*, and the mysids *Mysis litoralis* and *M. oculata*, are the most important animals in the intertidal zone and the nearshore barren zone. The same species of mysids as well as decapod crustaceans are important in deeper water.

The diet of Onisimus litoralis and O. glacialis appears to vary with time of year and age of the animal. As previously discussed, these species are herbivores when under the ice. In shallow nearshore waters, Onisimus litoralis is a scavenger (Steele 1961) that also feeds on disabled and tide-stranded zooplankton (MacGinitie 1955; LGL Ltd., unpubl. data). Divers have observed O. litoralis attacking and feeding on apparently live and healthy planktonic animals in the barren zone (Griffiths and Dillinger 1981; LGL Ltd., unpubl. data). Schneider and Koch (1979) indicate that O. litoralis may also feed heavily on diatoms during the open water period. It would appear that this amphipod is omnivorous and will feed on whatever is most readily available. Onisimus glacialis will also eat animal foods but appears to be more reliant on pelagic phytoplankton as a source of food (Griffiths and Dillinger 1981).

The feeding ecology of Gammarus setosus has been studied by Schneider and Koch (1979). They found that G. setosus was able to make efficient use of terrestrial peat and seaweed detritus as a food source, and could also function as a deposit feeder. They conclude that G. setosus, unlike most benthic animals, is able to derive its nutritional requirements from detritus directly without relying on its associated microorganisms. Gammarus setosus, seaweed fragments and detritus are all common on shorelines in the study area.

Recent work in the Beaufort Sea has shown that nearshore arctic mysids are omnivorous (Schneider and Koch 1979), but derive most of their nutritional requirements from the phytoplankton (Schell 1979).

Arctic decapod shrimp appear to feed mainly on phytobenthos and detritus; they occasionally eat foraminifera, crustaceans, gastropods, bivalves and polychaetes (Squires 1968).

4.4.2.3 Epifaunal Animals

Mussels, barnacles, bryozoans, crinoids, spirorbid polychaetes and holothurians (Psolus spp.) are all filter feeders. They are reliant on water movement for their supply of food and flourish in areas with a strong current (Curtis 1975). Sea anemones may capture large prey with their tentacles but are also capable of filter feeding with a mucous web (Barnes 1974).

4.5. Energy Flow

In the following discussion we attempt to trace the flow of energy from the lowest to the highest trophic levels in the pelagic food web of the eastern Lancaster Sound-western Baffin Bay region. The total area considered is the 237,000 km^2 covered by aerial surveys (Koski 1980a; McLaren 1980) and by marine studies conducted from MV Theron in 1978 (Sekerak et al. 1979).

Primary productivity for the period 23 July-10 October was estimated indirectly using the vertical distribution of light and chlorophyll in 1976 and 1978 (Sekerak et al. 1976b, 1979) and the results of primary productivity experiments conducted over a six-day period in early September 1977 by Irwin et al. (1978). Extrapolation of primary productivity rates determined over a six-day period in one year to a 2.5-month period in another year is a potential source of error in the calculations; the magnitude of the error is unknown.

Primary productivity of the ice algae and phytoplankton under bloom conditions have not been measured in the study area, and the values from Davis Strait that are used here are another source of undetermined error. It was not possible to determine confidence limits for our estimate of primary productivity.

Secondary productivity was estimated by extrapolating productivity-to-biomass ratios determined for two species of herbivorous zooplankton to the entire population of herbivores. The life history data used to calculate the productivity-to-biomass ratio for each of these two species were collected only over the 2.5 months of the 1978 EAMES study (Sekerak et al. 1979) and interpreted within the context of what is known about their life histories in other arctic areas. This source of error is compounded by the facts that the timing of the life cycle of the same species may vary from region to region in the study area, and that the same species may have an annual life cycle in one area and have a two-year life cycle in another. In addition, sampling was not conducted during some important parts of the life cycle. The magnitude of the error is unknown and we cannot place confidence limits on our estimates of secondary production.

Detailed information about the distribution and abundance of sea-associated birds and marine mammals is available. However, the abundance data provide only minimum estimates of numbers present, since some birds and mammals are inevitably missed during aerial surveys. It is not possible to determine the magnitude of the underestimation. The composition of the diets of most of these animals are comparatively well known. Some information concerning the quantities of food required by marine mammals is available, but the daily food requirements of seabirds are poorly known and may be a significant source of error. Our estimation of total consumption is based on minimum numbers of animals, imprecise knowledge of the nutritional requirements of seabirds, and no knowledge of any seasonal variation in the nutritional requirements of marine mammals.

The standing crop of arctic cod, about which no direct information is available, was estimated from the consumption of vertebrates using a method that underestimates true standing crop.

Because of these limitations in the data, the results cannot be interpreted rigorously. For example, it is not possible to determine if animals operating at the highest trophic level are food limited. Despite these very serious limitations, it was felt that an attempt at tracing energy flow in the pelagic ecosystem would be instructive in that major producers, consumers, and important links could be identified and the relative contribution of various components could be identified in at least a general way.

4.5.1 Primary Productivity

Annual primary productivity of the Lancaster Sound-western Baffin Bay area was estimated using chlorophyll a data (Sekerak et al. 1979), theoretical incident light (Budyko 1963 in Flohn 1969), measured light extinction in relation to depth (Sekerak et al. 1976b), and results of primary productivity experiments (Irwin et al. 1978).

Table 4.5.1. Primary productivity calculations for the eastern Lancaster Sound–western Baffin Bay region, 23 July–10 October 1978.

Depth (m)	23 July–18 August (Period 1)			19 August–17 September (Period 2)			18 September–10 October (Period 3)		
	Chl *a*[1] mg/m^3	Illumination[2] % of surface	Productivity mg C/m^3/d	Chl *a* mg/m^3	Illumination % of surface	Productivity mg C/m^3/d	Chl *a*[1] mg/m^3	Illumination % of surface	Productivity mg C/m^3/d
0	0.98 ± 0.56	88.1 ± 22.9	23.11	0.64 ± 0.52	81.7 ± 13.5	7.59	1.59 ± 0.71	81.4 ± 10.2	6.46
10	21.21 ± 0.98	18.5 ± 9.5	34.35	0.97 ± 0.82	19.3 ± 7.6	15.95	1.66 ± 0.48	16.4 ± 6.6	7.76
15	2.22 ± 2.06		48.31	1.57 ± 1.18		18.38	1.71 ± 0.46		5.86
25	1.86 ± 1.93	3.5 ± 3.0	8.79	2.49 ± 1.83	4.3 ± 2.7	7.91	1.78 ± 0.68	4.7 ± 2.7	2.14
40			0.75			2.31			
50	0.41 ± 0.40			0.49 ± 0.41		0.45	0.76 ± 0.65		0.39
	[3]80 ± 55 mg/m^2	200 ly/day	851 mg C/m^2/d	70 ± 34 mg/m^2	112 ly/day	425 mg C/m^2/d	139 ± 76 mg/m^2	37.5 ly/day	177 mg C/m^2/d

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[1] n = 23 for each period; from Sekerak et al. (1979).

[2] n = 15 for each of periods 1 and 2, and n = 5 for period 3; from Sekerak et al. (1976b).

[3] Depth-integrated totals.

Primary productivity in summer and fall can be estimated in the following manner. Irwin et al. (1978) performed experiments at five stations in western Baffin Bay and Lancaster Sound between 5 and 11 September 1977 and found primary productivity values of 0.0115 ± SD 0.0077, 0.0660 ± SD 0.0152 and 0.0560 ± SD 0.182 mg C/mg Chl a/w/h at depths of 0, 10 and 30 m, respectively. These productivity values were used to calculate mean daily productivity in each of three time periods from 23 July to 10 October 1978 using chlorophyll a data collected from 69 stations in 1978 and light extinction measurements made at six stations in 1976 (Table 4.5.1). Total productivity during these two and a half months is estimated at 39.8 g C/m^2. Productivity during the last 22 days is estimated at only 4.1 g C/m^2, and it is assumed that productivity is negligible after 10 October.

Primary productivity in spring must be estimated mainly from data collected outside the present study area. Surveys in 1976 and 1978 indicated that the spring bloom occurred prior to the beginning of shipboard field work. Data from nearby Wellington Channel, which is the source of 90 percent of the water that flows through Lancaster Sound, indicate that chlorophyll a concentrations of 3-5 mg/m^3 can be expected in the upper 25 m under bloom conditions (Bain et al. 1977). MacLaren Marex (1979b) found productivity-to-biomass ratios on the order of 0.45 mg C/mg Chl a/h and a euphotic zone of depth 15 m in Davis Strait during bloom conditions. However, chlorophyll a concentrations were much higher in Davis Strait (79-228 mg Chl a/m^2) than in Wellington Channel, and the euphotic zone was shallower in Davis Strait. For the purpose of this discussion we shall assume mean chlorophyll a concentrations of 4 mg/m^3 over a 25 m euphotic zone with a productivity-to-biomass ratio of 0.45 mg C/mg Chl a/h during a 23-day spring bloom in early July. Total primary productivity during the bloom period would be on the order of 25 g C/m^2.

Productivity of the epontic algae must also be considered when attempting to estimate total annual production in arctic waters. In Eclipse Sound, Cross (1980) found mean chlorophyll a values in the fast ice to be on the order of 440 mg Chl a/m^2 in May and 178 mg Chl a/m^2 in June. In studies of the epontic community in Davis Strait in April and May, MacLaren Marex (1979b) found productivity-to-biomass ratios of 0.191 ± SD 0.0309 and 1.548 ± SD 1.071 mg C/mg Chl a/d, respectively. Development of the epontic flora appears to occur about one month later in the high arctic (see Cross 1980), so these Davis Strait figures were applied to the chlorophyll a values from Eclipse Sound in May and June to yield productivity values of 83 mg $C/m^2/d$ in May and 276 mg $C/m^2/d$ in June, or 11 g C/m^2 of ice in May and June. Productivity values for May are consistent with the highest mean value (3.34 mg $C/m^2/h$) found experimentally by Cross (pers. comm.) at Cape Hatt, Baffin Island.

If the above contributions are totalled, the overall annual primary productivity of the Lancaster Sound-west Baffin Bay area is estimated at 76 g $C/m^2/yr$. Of this, 11 g C/m^2 (14 percent) is the contribution of the ice algae, 25 g C/m^2 is attributable to the spring phytoplankton bloom, and 38 g C/m^2 is attributable to phytoplankton later in the season.

Productivity of benthic plants is not considered, because shallow nearshore areas comprise less than four percent of the total area under consideration and most of this productivity enters the benthic food web.

The estimated total annual primary productivity of the Lancaster Sound-northwest Baffin Bay area appears high when compared to values obtained in the Beaufort Sea and Canadian arctic islands (Table 4.5.2). The estimated primary productivity approaches that found in the Bering Sea and is at the high end of the range of values found in Frobisher Bay. The apparently high primary productivity of the Lancaster Sound-northwest Baffin Bay area is reflected in the comparatively high biomasses of zooplankton and benthos found in the area (Tables 4.5.3 and 4.5.4). Biomass of both groups is higher in the present study area than in the central part of the Canadian arctic archipelago or the Beaufort Sea, and approaches values found in the highly productive Bering Sea (Tables 4.5.3 and 4.5.4).

4.5.2 Secondary Productivity

Productivity of zooplankton was estimated using life history information presented in Sekerak et al. (1979). Although these data only encompass the period from 26 July to 30 September 1978, the life cycles of arctic zooplankton are well known (see Grainger 1959; Cairns 1967; Dunbar 1968; Tidmarsh 1973) and it is possible to interpret data collected during the summer within the context of the annual cycle (see Sekerak et al. 1979).

4.5.2.1 Productivity of Calanus glacialis

Most *Calanus glacialis* require two years to reach maturity in the study area (Sekerak et al. 1979). It would appear that *C. glacialis* spend their first winter as stage II and III copepodites, mature to stage IV and V during the following summer, and mature to adults one year later. The fact that adult females were found in Wellington Channel in June (Bain et al. 1977) and that large numbers of early copepodite stages were found in the study area in late September (Sekerak et al. 1979) indicated that most breeding takes place in summer. The life history data shown below, the above interpretation of the life cycle, and individual weights (Bradstreet 1976) were used to calculate the productivity-to-biomass ratio of *C. glacialis*.

The gain in biomass of the population through one year was calculated as follows. It was assumed that all of the stage II and III copepodite stages found from 10 September to 30 September were produced that year and that after the sampling period, half of the stage II animals would mature to stage III and all of the stage I animals would mature to stage II before winter for a net gain of 687 mg/m^2 wet weight. Young of the previous year are presumed to have overwintered as stage II and III and evidence presented by Bain et al. (1977) indicates that maturation to stage IV begins during the spring bloom. If 75 percent overwintered as stage II and 25 percent as stage III (from our first assumption) then maturation to the observed densities of stage IV and V on 26 July to 5 August (Table 4.5.5) would entail a gain 2455 mg/m^2. At least 637 mg/m^2 stage V individuals matured to adults over the summer for a gain of 688 mg/m^2. Animals that overwintered as stage IV individuals must mature through stage V at some point for a gain of 968 mg/m^2. The total gain before the first sampling period is 4798 mg/m^2 wet weight. McLaren (1969) estimated that nine to 30 percent of the productivity of two high arctic copepods was due to egg production. However, each of these species had an annual life cycle. For our purposes a conservative

Table 4.5.2. Annual productivity from eight locations in the North American Arctic.

Area	Year	Primary productivity (mg $C/m^2/yr$)	
Bering Sea	several	75-150	Ikeda and Motoda (1978)
Northeast Chukchi Sea	1976	18	Carey (1978)
	1977	28	Carey (1978)
Western Beaufort Sea	1976	9	Carey (1978)
	1977	18	Carey (1978)
Dumbell Bay, Ellesmere Is.		9-12	Apollonio (1976a)
Resolute Bay, Cornwallis Is.	1971-72	32	Welch and Kalff (1975)
Jones Sound	1961-72	35	Apollonio (1976b)
	1963	20	Apollonio (1976b)
Lancaster Sound	1978	76	This report
Frobisher Bay	1968	40	Grainger (1975a)
	1969	70	Grainger (1975a)

Table 4.5.3 Comparison of the mean biomass of zooplankton from arctic and subarctic waters.

Location	Date	Depth sampled (m)	Mean biomass (mg/m^3)	Source
Lancaster Sound	23 July-10 October 1978	0-50	399.9	Sekerak *et al*. (1979)
		0-150	189.8	
		0-250	156.5	
	July-September 1976	0-150	171-284	Sekerak *et al*. (1976b)
Bering Sea	Summer	0-150	402.7	Ikeda and Motoda (1978)
Canadian arctic islands				
Foxe Basin	Summer	0-100	55	Grainger (1962)
Assistance Bay, Cornwallis Is.	July-August	0-50	80	Mohammed and Grainger (1974)
Slidre Fiord, Ellesmere Is.	July-August	0-50	84	Mohammed and Grainger (1974)
Creswell Bay, Somerset Is.	July-August	0-50	192	Mohammed and Grainger (1974)
Wellington Channel	June	0-50	156	Bain *et al*. (1977)
Bridport Inlet	June	0-50	44	Buchanan *et al*. (1977)
	August	0-50	154	Buchanan *et al*. (1977)
	August	0-120	34	Buchanan *et al*. (1977)
Frobisher Bay, Baffin Is.	Summer	0-50	160-330	Grainger (1971)
Atlantic Ocean				
Labrador Current	Fall	0-200	1072	See Be *et al*. (1971)
Norwegian Sea (temperate)	Yearly	0-100	500	See Be *et al*. (1971)
Norwegian Sea (subarctic)	Yearly	0-300	100	See Be *et al*. (1971)

Table 4.5.4. Comparison of the mean integrated biomass (g/m^2) of benthic infaunal animals from arctic and subarctic areas. Only the depth range from five to 50 m is considered.

Location	Sample size	Mean biomass (g/m^2)	Source
Bering Sea	?	475	Alton (1974)
Alaskan Beaufort Sea	131	41	Carey (1977)
Bridport Inlet, Melville Is.	78	94	Buchanan et al. (1977)
Brentford Bay, Boothia Pen.	21	188	Thomson et al. (1978)
EAMES study area	110	319	Thomson and Cross (1980)
Lancaster Sound	25	520	Thomson and Cross (1980)
NW Baffin Bay	52	297	Thomson and Cross (1980)
Eclipse Sound	19	258	Thomson and Cross (1980)
Central Baffin Bay	14	88	Thomson and Cross (1980)
Northern Baffin Is.	51	200-438	Ellis (1960)
Labrador coast (infauna only)	94	346	Barrie et al. (1980)
Newfoundland banks	6	1455	Nesis (1965)

Table 4.5.5. Mean density (no./m2, 0-1200 m) of the life stages of *Calanus glacialis* in eastern Lancaster Sound and western Baffin Bay in 1978 (from Sekerak *et al*. 1979).

Date	No. of Stations	Copepodite Stage					
		I	II	III	IV	V	Adult
25 July-5 Aug.	13	620	170	279	787	2069	490
5 Aug.-26 Aug.	5	154	193	167	320	2424	637
27 Aug.-9 Sept.	9	786	310	341	336	2475	507
10 Sept.-30 Sept.	6	4011	2046	665	369	1783	372
Mean weight per individual (mg)			0.07	0.20	0.47	1.15	2.23

estimate of 10 percent will be used. Total annual productivity is, therefore, on the order of 5331 mg/m^2. The mean biomass of *C. glacialis* over the sampling period was calculated by multiplying the mean density of each life stage over the period by its weight. The mean biomass was 3992 mg/m^2 and the productivity-to-biomass ratio would be on the order of 1.34. These calculations underestimate the productivity of *C. glacialis* because (1) young-of-the-year born and consumed before the last sampling period are not considered, (2) weight gain without maturation in preparation for overwintering is not considered, (3) some populations in the study area have a one-year life cycle, and (4) older stages maturing and consumed before the first sampling period are not considered.

4.5.2.2 Productivity of Pseudocalanus minutus

The life cycle of *Pseudocalanus minutus* in the study area was more difficult to interpret. *P. minutus* appears to have an annual cycle in some regions and requires two years to reach maturity in others (Fig. 67 in Sekerak *et al*. 1979). Productivity was, therefore, calculated in a different manner.

Sekerak *et al*. (1979) grouped their stations on the basis of similarity of copepod life stages. Data from one of these groups (stations A4, D4, E4) were used to calculate the gain in biomass of immature stages between 26 July and 30 September.

The increase in mean density of each immature life stage (Table 4.5.6) was multiplied by the mean weight of each immature life stage (McLaren 1969). The sum of these values is 6469 mg C/m^2. The maturation of stage V individuals to adults prior to sampling would entail an increase of 3013 mg C/m^2. It is assumed that no further growth occurs after the end of September (see McLaren 1969) and that 30 percent of total production is due to production of eggs (McLaren 1969). Total productivity of the population would be on the order of 13,546 mg C/m^2 from a mean standing crop of 8003 ug C/m^2 (mean biomass calculated from Table 4.5.6). Thus the productivity-to-biomass ratio would be about 1.69.

This estimate of secondary production is also an underestimate. Neither production prior to the onset of sampling nor production consumed during the sampling period is considered.

Table 4.5.6. Mean density (no./m^2) of life stages of Pseudocalanus minutus at stations A4, D4 and E4 (Sekerak et al. 1979).

Copepodite Stage	Mean weight per Individual mg C^1	26 July-2 August	2-5 September	29-30 September
I	0.13	50	1155	400
II	0.32	206	2491	2008
III	0.66	258	1506	2592
IV	1.05	147	711	1680
V	1.95	176	938	1559
Adult	3.5	1944	829	358

[1] From McLaren (1969).

4.5.2.3 Productivity of the Zooplankton as a Whole

The mean standing crop of zooplankton in the western Baffin Bay-Lancaster Sound area from 23 July to 10 October in 1978 was 137.8 g/m^2 wet weight (Sekerak et al. 1979) or 8.31 g C/m^2 (Carbon = 0.45 times dry weight, dry weight = 0.15 times wet weight; Ikeda and Motoda 1978). Herbivorous zooplankton acounted for 6.757 g C/m^2, or 81 percent of the total.

The mean of the calculated productivity-to-biomass ratios for the two species discussed above (1.52) yields a value of 10.271 g C/m^2 as the productivity of herbivorous zooplankton. This value is 14 percent of estimated primary productivity and as such is at the lower limit of accepted energy transfer efficiencies at the first trophic level (Parsons et al. 1977).

The calculated productivity-to-biomass ratio of 1.52 for the herbivorous zooplankton of Lancaster Sound is low when compared to values from other marine areas (Table 4.5.7). The difference is perhaps attributable to the longer life cycles of high arctic animals. The ratio is higher in Ogac Lake and the Bering Sea, where zooplankton complete their life cycle in one year, and much higher in temperate latitudes where several generations are produced in a year.

The mean biomass of carnivorous zooplankton was 37.7 g/m^2, or 1.56 g C/m^2 using conversion factors from Parsons et al. (1977) for individual groups to convert wet weight to carbon. McLaren (1969) found that the productivity-to-biomass ratio of an annual carnivore was only slightly lower than that of herbivores. We have no comparable data and will use the estimate of 1.52 derived for herbivores. Production of carnivorous zooplankton is, therefore, on the order of 2.3 g C/m^2/yr. The calculated efficiency of the transfer of energy from the first to the second trophic level in Lancaster Sound and western Baffin Bay, 23 percent, is comparable to that in other marine areas (Table 4.5.7; cf. Parsons et al. 1977).

Table 4.5.7. Primary and secondary productivity, energy transfer efficiencies, and productivity to biomass ratios for various marine areas.

Area	Primary Productivity (g C/m^2/yr)	Transfer Efficiency %	Herbivorous Zooplankton		Transfer Efficiency %	Carnivorous Zooplankton (g C/m^2/yr)	Source
			Productivity (g C/m^2/yr)	P/B			
Western Baffin Bay, Lancaster Sound	76	14	10.3	1.52	23.0	1.9	This report
Ogac Lake, Baffin Is.	9	9.5	0.85	2.4-3.4	33.8	0.287	McLaren (1969)
Bering Sea	89	14.9	13.3	3.3-5.4			Ikeda and Motoda (1978)
Ocean Station P, Pacific Ocean	65	20	13.0				McAllister (1969)
North Sea	800*	22	175*	7			Crisp (1975)

* Units for North Sea data: kcal/m^2/yr.

4.5.3 Consumption by Marine Mammals and Seabirds

Relatively detailed information is available concerning the distributions and abundances of the top level carnivores in Lancaster Sound and western Baffin Bay. This information comes largely from the extensive aerial surveys that were flown in 1976, 1978 and 1979. Considerable pertinent information is also available concerning the life histories, population structure, feeding habits and daily ration of many of major seabird and marine mammal species inhabiting the area.

Numbers of mammals and seabirds in the area are presented in Table 4.5.8. They are derived from the results of aerial surveys (Koski 1980a; McLaren and Renaud 1979; McLaren 1980) and from data in Gaston (1980) and Nettleship and Gaston (1978).

Mean weights of ringed seal and narwhal (Table 4.5.8) were estimated from the age structure of the population and age-weight relationships provided by Parsons (1977) and Hay (unpubl. data). Given the structures of the population, Sergeant (1973a) has estimated the mean weight of a harp seal to be 100 kg (not including young). Mean weight of a narwhal was used to estimate that of a white whale. The weight of a medium-sized bowhead (length 10 m) was calculated from data provided by Scoresby (1820). Weights of seabirds are based on collections by M.S.W. Bradstreet (LGL Ltd. unpubl. data).

The daily ration of wild ringed seals has been calculated to be 6 percent of body weight (Parsons 1977). Captive harp seals eat 6.9-8.4 percent of body weight per day, and Sergeant (1973a) estimates consumption in the field to be 4.1 percent of body weight per day averaged over a year. When the spring fasting period is excluded, harp seals consume five percent of body weight per day. Daily rations for narwhals and white whales (five percent of body weight) are based on Sergeant's (1969) calculations for small cetaceans. The estimated daily intake of a fin whale (three percent of body weight; Brodie 1975) was used to approximate that of a bowhead.

Data presented by Weins and Scott (1975) suggest that breeding murres consume 13 to 29 percent of body weight per day. However, using experimental techniques, Johnson and West (1975) have shown that standard metabolism alone is 6.26 cal/h or 135 kcal/day for a 900 g murre. This is equivalent to 135 g wet weight of fish (Bradstreet 1976) or 15 percent of body weight per day. If the bird flies only two hours per day, it will expend another 200 kcal (Tucker 1974) or 22 percent of body weight per day. Feeding of young during the 20-day chick-rearing period requires a further 48 g/day (Tuck 1961) per parent, which is another five percent of body weight. When not feeding young, adults are generally moulting, migrating, producing eggs or incubating, all of which consume energy. In the following computations we shall use a daily ration of 42 percent of body weight for murres. In the absence of information for other species, we apply this figure to other seabirds as well.

Total annual consumption by each major species is shown in Table 4.5.8, and consumption of major prey is shown in Table 4.5.9. Ringed seals consume the greatest amount of food, followed by thick-billed murres and narwhals. In the study area, the arctic cod is the major source of food both for seabirds (65 percent of all food) and marine mammals (50 percent). Consumption in terms of grams of carbon, based on Bradstreet's (1976) and Ikeda and Motoda's (1978) conversion factors, is shown in Table 4.5.10.

Table 4.5.8. Total annual consumption by marine mammals and seabirds in eastern Lancaster Sound and western Baffin Bay.[1]

Species	Estimated No. in area	Mean weight (kg)	Biomass (g/m^2)	Daily ration (% of body weight)	Time in area (days)	Consumption
						g/m^2 wet weight
Ringed seal	500,000	33	0.0696	6.0	365	1.5247
Harp seal	16,000	100	0.0068	5.0	90	0.0304
Narwhal	20,000	475	0.0401	5.0	75	0.1503
White whale	10,000	475	0.0200	5.0	20	0.0200
Bowhead whale	250	30,000	0.0316	3.0	90	0.0854
Thick-billed murre	800,000	0.900	0.0030	42.0	120	0.1512
Northern fulmar	250,000	0.725	0.0008	42.0	130	0.0418
Dovekie (May)	10,000,000	0.150	0.0063	42.0	15	0.0399
(June-Oct)	500,000	0.150	0.0004	42.0	120	0.0160
Black guillemot	30,000	0.425	0.0001	42.0	150	0.0034
Black-legged kittiwake	150,000	0.400	0.0003	42.0	135	0.0144

Sources: Total numbers and time in area: Davis et al. 1978a; Koski and Davis 1979; McLaren and Renaud 1979; 1980; Gaston 1980; McLaren 1980; Finley et al. 1982. Mean weights: Scoresby 1820; Sergeant 1973a; Parsons 1977; K. Hay unpubl. data; M.S.W. Bradstreet unpubl. data.

Daily Rations: Sergeant 1969; Brodie 1975; Parsons 1977; Finley and Gibb MS; birds, see text.

Carbon = 0.45 dry weight; dry wt. = 0.15 x wet weight (Ikeda and Motoda 1978); 0.20 x wet weight for fish (Bradstreet 1976).

[1] Area considered is 237,000 km^2.

Table 4.5.9. Annual consumption of major food items of marine mammals and seabirds in eastern Lancaster Sound and western Baffin Bay.

	Annual Consumption[1] (wet weight)								
	Total	Arctic cod		Other fish+ Cephalopods		Herbivorous zooplankton		Carnivorous zooplankton	
Species	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2
Ringed seal	1.5247	50	0.7624	-	-	25	0.3812	25	0.2812
Harp seal	0.0304	66	0.0201	34	0.0103	-	-	-	-
Narwhal	0.1503	71	0.1067	29	0.0436	-	-	-	-
White whale	0.0200	71	0.0142	29	0.0058	-	-	-	-
Bowhead whale	0.0854	-	-	-	-	100	0.0854	-	-
Mammal Total	1.8108	50	0.9034	3	0.0597	26	0.4666	21	0.3812
Thick-billed murre	0.1512	83	0.1255	-	-	-	-	17	0.0257
Northern fulmar	0.0418	50	0.0209	-	-	16	0.0067	33	0.0138
Dovekie	0.0559	19	0.0106	-	-	40	0.0224	40	0.0224
Black guillemot	0.0034	71	0.0024	-	-	15	0.0005	15	0.0005
Black-legged kittiwake	0.0144	92	0.0132	-	-	8	0.0012	-	-
Seabird Total	0.2667	65	0.1726	-	-	12	0.0308	23	0.6244
Grand Total	2.0775	52	1.0760	3	0.0597	24	0.4974	21	0.4436

[1] Feeding habits are from sections 4.1 and 4.2.

In historic times the population of bowhead whales was much larger than at present. From data presented in Ross (1979), it is evident that around the year 1800 at least 10,000 bowhead whales must have been present in the study area during summer. This population estimate is little better than a guess but will illustrate the effect of a large population of whales on the system. Ten thousand bowheads with a mean weight of 30,000 kg spending 90 days in the study area and channels to the west and with a daily ration equivalent to three percent of body weight (Brodie 1975) would consume 3.5 g/m^2 wet weight or 0.2408 g C/m^2 over the season. This is about 1.5 times the estimated amount currently consumed by all seabirds and marine mammals (Table 4.5.8).

Table 4.5.10. Annual consumption (g C/m^2) of major prey by seabirds and marine mammals.

	Zooplankton		Arctic Cod	Other Fish+ Cephalopods	Total
	Herbivores	Carnivores			
Seabirds	0.0021	0.0042	0.0155	-	0.0218
Marine mammals	0.0315	0.0257	0.0813	0.0054	0.1439
Total	0.0336	0.0299	0.0968	0.0054	0.1657

4.5.4 Arctic Cod

The biology of this important species has been discussed previously. No direct attempt to estimate the numbers of arctic cod in the study area has been made; however, an indirect estimate of abundance may be arrived at through a consideration of the amount consumed by marine mammals and seabirds.

The lengths of 18,004 arctic cod consumed by seabirds and marine mammals were estimated from the sizes of cod otoliths taken from the stomachs of seabirds (Bradstreet 1976), harp seals and narwhals (Finley and Gibb in press, MS) and ringed seals (Finley pers. comm.). The age-length relationship of Canadian high arctic cod (Bain and Sekerak 1978) was used to estimate the age structure of fish consumed.

The stomach contents of 62 harp seals yielded the otoliths of 5877 arctic cod. The age-frequency distribution of these cod, and the previous estimate of the total amount of cod consumed by harp seals, were used to estimate the total consumption of each year class of arctic cod in the study area (Table 4.5.11). Similar computations were performed on cod consumed by seabirds, narwhals (also used for white whales) and ringed seals (Table 4.5.12). An estimated 23.7 x 10^9 arctic cod are consumed annually by the major species of marine mammals and birds in the study area.

Table 4.5.11. Consumption of arctic cod of various ages by 62 harp seals, and estimated consumption by 16,000 harp seals in the study area.

	Year Class of Arctic Cod					
	1^+	2^+	3^+	4^+	5^+	Total
No. fish consumed[1]	999	3293	702	754	129	5877
Mean wet weight of fish (g)[2]	1.62	18.27	32.16	40.53	62.40	
Total weight consumed (g)	1618	60,163	22,575	30,559	8049	122,966
% by weight	1.3	48.9	18.4	24.9	6.5	
Consumption in study area (tonnes)	62	2329	877	1186	310	4763[3]
Total no. consumed in study area ($\times 10^6$)	39	128	27	29	5	228

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[1] From Finley and Gibb (MS).

[2] From Bradstreet (1976).

[3] From Table 4.5.9--0.0201 g/m^2 over an area of 237,000 km^2 = 4700 tonnes. This amount is apportioned among year classes according to the percentages in the previous line.

Derzhavin's biostatistical method (Ricker 1975) was used to estimate the total population in the study area (Table 4.5.13). In this method, the total stock is the sum of the total catch, plus the next year's catch of age two and older fish, not including the first year class, and so on for subsequent years (see Ricker 1975). Our computations do not include the 0^+ age class, which does not form part of the exploited population. The method does not allow for mortality from causes other than predation, and thus underestimates the true population (Ricker 1975). If our estimate (Table 4.5.12) of annual consumption of arctic cod is close to reality, then our estimate of total numbers of cod is a minimum one. These computations assume constant annual recruitment, constant annual consumption, and recruitment equal to consumption.

The minimum population of arctic cod greater than one year old is estimated at 39×10^9 individuals with a total standing crop of 403×10^9 g wet weight (403,000 metric tons) or 1.7 g/m^2 wet weight (0.15 g C/m^2). Craig and Haldorson (1981) estimate that arctic cod consume six percent of their body weight per day. Using this figure and our minimum estimate of the standing crop of arctic cod, arctic cod would consume a minimum of 3.354 g C/m^2/yr.

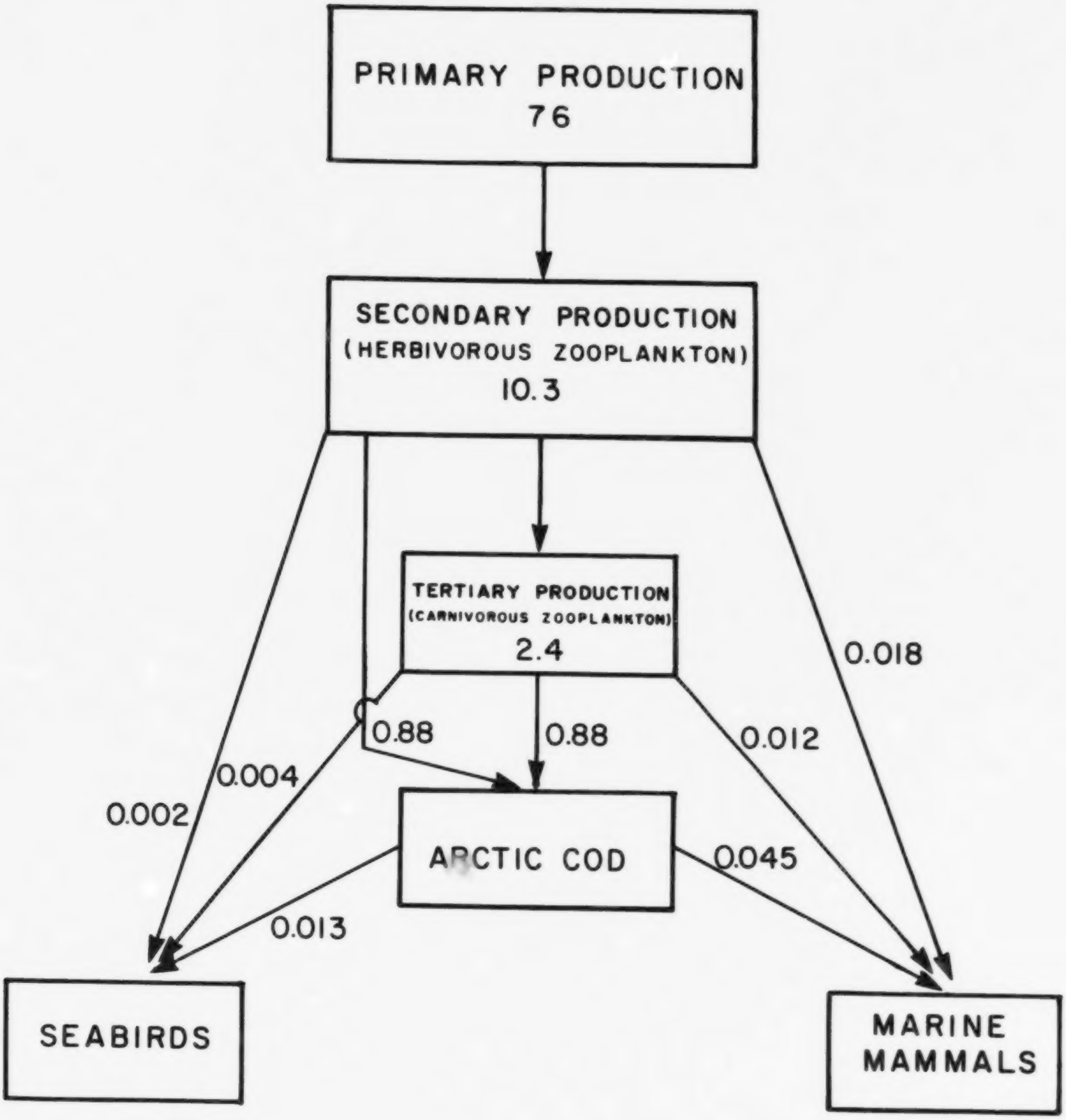
PRIMARY PRODUCTION
76
SECONDARY PRODUCTION
(HERBIVOROUS ZOOPLANKTON)
10.3
TERTIARY PRODUCTION
(CARNIVOROUS ZOOPLANKTON)
2.4
0.018
0.88
0.88
0.012
0.004
0.002
ARCTIC COD
0.045
0.013
SEABIRDS
MARINE MAMMALS

FIG. 4.5.1 Schematic representation of energy flow (g $C \cdot m^{-2} \cdot yr^{-1}$) in eastern Lancaster Sound and western Baffin Bay. Arrows indicate the direction of flow and associated numbers indicate the annual magnitude. Numbers within boxes are estimated annual production.

Table 4.5.12. Total consumption of arctic cod of various ages by seabirds and marine mammals in the study area.

Year class of arctic cod	Estimated Number of Cod ($\times 10^9$) Consumed by				
	Seabirds	Harp seal[1]	Ringed seal	Narwhal White whale	Total
1^+	1.540	0.039	11.711	0.531	13.821
2^+	1.319	0.128	4.114	1.101	6.662
3^+	0.444	0.027	1.646	0.179	2.296
4^+	-	0.029	0.823	0.046	0.898
5^+	-	0.005	0.017	0.001	0.023
Total No. Arctic Cod ($\times 10^9$)	3.303	0.228	18.311	1.858	23.700
Total Wet Weight of Arctic Cod (tonnes)[2]	40,906	4763	180,689	28,653	255,001
Mean Wet Weight per Arctic Cod (g)	1.35	20.89	9.8	15.42	10.8

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[1] From Table 4.5.11.

[2] From Table 4.5.9--the 'g/m^2' arctic cod consumption data are applied to an area of 237,000 km^2.

4.5.5 Summary

Figure 4.5.1 summarizes the pattern of energy flow itemized in the previous discussion. In spite of the limitations of the data, the following statements about energy flow in the Lancaster Sound-western Baffin Bay area may be made with a reasonable degree of confidence:

1. Primary and secondary productivity were estimated independently and their relative magnitudes are consistent with the proportions reported for other areas (secondary is 14 percent of primary). An energy transfer efficiency of 14 percent between the first two trophic levels is consistent with the rate of energy transfer found in other northern marine areas (Table 4.5.7). Estimated primary productivity in the study area is high (76g $C/m^2/yr$) and this is reflected in a high standing crop of zooplankton and infaunal benthos.

2. The estimated productivity-to-biomass ratio of herbivores (1.52) is quite low when compared to that of other marine areas, presumably because of the longer life cycles of high arctic zooplankton. Thus, the high productivity of the zooplankton results from a high standing crop, not from an unusually high productivity-to-biomass ratio.

Table 4.5.13. Calculation of minimum number of arctic cod in eastern Lancaster Sound and western Baffin Bay based on Derzhavin's method (Ricker 1975).

Year class	Total consumption	Fractional age representation	Cumulative age composition	Contribution to population	Total population	Mean wt (g)	Total weight of population (g)
1^+	13.821×10^9	0.583	0.583	10.086×10^9	23.907×10^9	1.62	38.729×10^9
2^+	6.662	0.281	0.864	3.424	10.086	18.27	184.271
3^+	2.296	0.097	0.961	1.1280	3.424	32.16	110.1158
4^+	0.898	0.038	0.999	0.230	1.128	49.53	55.870
5^+	0.230	0.001	1.000	0.000	0.230	62.40	14.352
Total	23.700	1.000			38.775		403.338

3. Arctic cod account for about 52 percent of the total amount of food consumed in the study area by marine mammals and marine birds. Thus, the arctic cod is the major link in the transfer of energy from lower to higher trophic levels.

4. The arctic cod is the major vertebrate consumer in the study area. Based on our minimum estimates of the numbers of cod of various ages in the study area (Table 4.5.13), consumption by cod is at least 20 times greater than by marine mammals and seabirds combined (cf. Table 4.5.10).

5. Marine mammals consume almost seven times as much energy as seabirds. Among these animals, ringed seals consume the largest amount, followed by narwhals, thick-billed murres, bowhead whales and dovekies.

6. In historic times, the bowhead whale was more important as a consumer than any other marine mammal (or bird) in the region. Bowheads consumed about 1.5 times as much as all other marine mammals and seabirds combined, and slightly more than arctic cod. In this respect, the study area was similar to the antarctic. Because bowheads feed primarily on zooplankton, a larger proportion of the total energy consumed by birds and mammals flows through arctic cod now than in pre-whaling times.

5.0 IMPORTANT FACTORS AND PROCESSES

Lancaster Sound has long been known for its concentrations of seabirds and marine mammals. The region also supports higher standing crops of benthic invertebrates than most other areas of the North American Arctic that have been studied (Thomson and Cross 1980). Zooplankton standing crop also appears to be unusually high and, at least in some years, there is a large standing crop of phytoplankton (Sekerak et al. 1979). Thus, most lower trophic levels occur in considerable numbers, and food for vertebrates appears to be abundant.

This chapter describes processes and factors that may lead to the apparently high productivity of all forms of marine life in the eastern Lancaster Sound-western Baffin Bay area. Processes that result in high primary productivity are addressed first, and then factors involved in causing the high diversity and numbers of marine animals are discussed.

5.1 Processes Leading to Higher Primary Productivity

Plants ultimately support all food webs. It is generally held that nutrient availability, especially that of nitrogen, usually limits plant production in the Arctic. Therefore, considerable interest has arisen in identifying mechanisms (other than the widespread winter renewal of nutrients, mineralization and recycling) that could enhance nutrient concentrations in the region for brief or prolonged periods of time. The following sections synthesize information obtained on such mechanisms in the study area, as well as in other arctic regions. Processes that could enhance availability of food organisms of vertebrates are discussed in Section 5.2.

5.1.1 'Nonglacial' Streams and Rivers

Substantial amounts of nitrates are carried into the sea by streams and rivers. Grainger (1975b) has shown that the Mackenzie River adds significant quantities of nitrate and silicate into the coastal waters of the Beaufort Sea. Sekerak and Graves (1975) found total dissolved nitrogen concentrations in streams and lakes of the lower central arctic islands and the Boothia Peninsula to vary from 3.6 to 32 mg-at N/m^3. Buchanan et al. (1977) found the Mecham River, which flows into Bridport Inlet on southern Melville Island, to contain 4.7 mg-at nitrate + nitrite/m^3, whereas surface waters of the inlet contained a maximum of 0.9 mg-at N/m^3 in mid-August. Thomson et al. (1978) found a concentration of 7.6 mg-at nitrate + nitrite/m^3 near the mouth of a small river draining into Brentford Bay, Boothia Peninsula, in early September. Concurrently, nitrate + nitrite were undetectable in surface water at two locations farther offshore.

Available information suggests that nonglacial freshwater streams supply nitrates to arctic marine waters. However, this phenomenon is widespread in the arctic and no unusually large rivers are present in the region. Thus, it does not appear to explain the apparent high primary production in Lancaster Sound and adjacent areas in comparison to most other arctic regions.

5.1.2 Glacial Runoff

Glacial meltwater enters Lancaster Sound and Baffin Bay through defined stream channels, directly from glacier faces, and from melting icebergs. Apollonio (1973) found significantly higher nitrate concentrations in the upper 75 m of glaciated South Cape Fiord than in unglaciated Grise Fiord or Jones Sound. He attributed the nutrient enhancement of South Cape Fiord to glacial erosion of limestone and its entry into the sea with runoff, although he did not measure the nutrient levels of the glacial runoff before it entered the sea.

To further investigate the importance of nutrients in glacial runoff, measurements were obtained in the present study area in 1978 (Sekerak et al. 1979). Direct runoff from the glacier at Cape Warrender contained 4.2 mg-at nitrate + nitrite/m^3. A stream receiving glacial meltwater and entering Erik Harbour, northeast Baffin Island, contained 2.0 mg-at nitrate + nitrite/m^3, and a stream in the same area that was not directly influenced by glacial runoff contained only 0.3 mg-at/m^3. Surface waters in Erik Harbour, 0.8 km from a glacier face, contained 0.8 mg-at nitrate + nitrite/m^3. Surface waters at a nearby station (G-1) contained $>$0.3 mg.at N/m^3 at the same time. Nitrate concentrations measured along transects at various distances from Philpots Glacier and Phoenix Head Glacier, southeast Devon Island, did not exhibit any enhancement from glacial runoff (Sekerak et al. 1979). These data support those of Apollonio (1973) in showing that glacial meltwater, at least from some glaciers, contains somewhat higher concentrations of nitrate + nitrite than surface waters of the surrounding sea in late summer and fall. However, it would appear from the limited available data that glacial runoff does not contain unduly large amounts of nitrates in comparison to nonglacial streams. Glacial discharge into the comparatively open waters of Lancaster Sound apparently was not sufficient to produce a build-up of nitrate, in contrast to the situation in the relatively small and enclosed South Cape Fiord (Apollonio 1973) or, perhaps to a lesser extent, in Erik Harbour.

Crude approximations of the amount of nitrate entering the sea from glacial runoff can be made by assuming that glaciers are presently in equilibrium (not advancing or retreating), and that average glacial runoff is equal to annual precipitation. Records from 1941 to 1970 suggest that annual precipitation in the study area is between 10 and 15 cm (Atmospheric Environment Service, n.d.), although Walker and Lake (1975) indicate that these may be underestimates. Glaciers and ice caps on the portions of Devon Island and Bylot Island that drain into Lancaster Sound occupy an area of roughly 10,300 km^2. If annual precipitation is taken as a liberal 30 cm, a total annual discharge of 3.1 km^3 can be calculated. Using an average concentration of 3 mg-at N/m^3, 9300 kg of nitrate could enter the sea from glacial runoff per year.

In comparison to the above, winter renewal processes likely provide about 4.6 million kg of nitrate when one considers only a moderate portion of the study area. This approximation is based on a section of Lancaster Sound 210 km long by 90 km wide by 35 m deep, the average depth of the euphotic zone (Sekerak et al. 1976b). We assume that this process increases the nitrate concentration throughout this volume to 7.0 mg-at N/m^3 (a common concentration of nitrate found in deeper waters of Lancaster Sound). This crude estimate suggests that nitrate entering the sea from glacial runoff may be only about 0.2 percent of that provided by winter renewal processes. Thus nutrient enrichment via glacial runoff cannot have a significant effect on the overall productivity of the area, but might have local effects because of the localized distribution of major outflows into the sea.

5.1.3 Upwelling at Glacier Faces

Hartley and Dunbar (1938) reported that freshwater runoff and outflow from a glacier face that extended into the sea in west Greenland produced entrainment of deeper water; this water upwelled near the glacier face. Such an occurrence is similar to entrainment of deep waters in estuaries. Although nutrient concentrations were not measured by Hartley and Dunbar (1938), it can be presumed that water relatively rich in nutrients was being transported upward to regions where the nutrients could be utilized by plants. To our knowledge, this phenomenon has not been studied subsequently. Although it could theoretically enhance production of coastal areas in the study area, it appears that such an upwelling process would have only limited and local effects.

5.1.4 Icebergs

It has been hypothesized that icebergs could enhance local nutrient concentrations in two ways:

1. by inducing upwelling at their sea faces (Dunbar 1973), and
2. from runoff of nutrient-rich meltwater (Sekerak et al. 1979).

Sekerak et al. (1979) sampled surface (0 m) waters around a tabular 1.6 million tonne iceberg (13 m above water line at the highest point) in northwest Baffin Bay in early September 1978. Twelve transects radiating from the iceberg were sampled at one, 50, and 100 m distances from the iceberg. No evidence of nutrient enhancement was obtained. In fact, average nutrient concentrations near the iceberg tended to be lower, not higher, than those elsewhere in the area. Unfortunately, samples from the iceberg itself were not obtained for nutrient analysis, and deeper water was not sampled. The keel of an iceberg of this size could extend to a depth of over 100 km, and water currents at 0 and 100 m can differ (Fissel et al. 1981). Movement of such a massive object through the water must create considerable vertical water turbulence and could be a source of local nutrient enhancement of surface waters. However, the overall ecological significance of this local enhancement, should it occur, is thought to be small.

5.1.5 Upwelling at Ice Edges

Clarke (1978) predicted that strong winds could produce a strong surface current moving away from an ice edge, and that this could entrain deeper, nutrient-rich water and bring it to the surface. Buckley et al. (1979) documented this phenomenon at a pack ice edge north of Spitzbergen. The effect of wind on surface water is modified by the presence of an ice edge and will cause a divergence at the ice-water boundary. Buckley et al. (1979) found that the displaced arctic water was replaced by Atlantic water from a depth of 150 m. Bain et al. (1977) reported isohaline and isothermal conditions and uniformly high nutrient concentrations in the upper 25 m of water at a fast ice edge across Resolute Passage on 5 July 1976, after high winds blew off the ice the day before. They tentatively attributed these conditions to wind-induced upwelling at the ice edge. In contrast, the water column at the fast ice edge in nearby Wellington Channel was stratified and nutrients were depleted in the upper 25 m of water. Cross (1980) reported no evidence of upwelling at the Pond Inlet ice edge in May and June 1979; however, high winds did not occur during their study.

Sufficient information is now available to identify upwelling at fast ice edges as a nutrient enhancement mechanism, but the frequency of such occurrences or their overall significance is unknown. Pulses of nutrients that would increase primary production could be brought to the surface at many ice edges in or adjacent to the study area (Pond Inlet, Jones Sound, Lancaster Sound, Barrow Strait, Wellington Channel, and Resolute Passage).

5.1.6 Wind-Induced Upwelling Near Shorelines

The interactions of winds, currents and shorelines produce well known, large and predictable areas of upwelling along the coasts of Africa, Peru, California and elsewhere (Parsons et al. 1977; Raymont 1980). Such areas are unknown in the Arctic, but local upwelling might occur as a result of strong winds coming off the land. The extremely strong winds (e.g., over 100 km/h) that blow down some valleys of Greenland are well known; the winds are generated by cold dense air from the Greenland ice cap. Strong north winds (80-100 km/h) recorded in Dundas Harbour, south of Devon Island, are believed to have arisen through the same mechanism. Buchanan et al. (1977) found nutrient concentrations in Bridport Inlet in late August 1977 to be somewhat higher than expected, and hypothesized that the strong winds observed in mid-August may have induced some vertical mixing. The significance of wind-induced upwelling near arctic shorelines cannot, however, be assessed from presently available information.

5.1.7 Fronts

Fronts may be defined as relatively narrow bands of water where abrupt changes in density occur over relatively small horizontal distances (Cromwell and Reid 1956). Fronts can be produced when opposing currents are near to one another, and are of great biological interest because vertical mixing of waters at the front can bring deep nutrient-rich water into the euphotic zone. Accumulation of food organisms can also occur and some fronts may be extremely important feeding areas for seabirds and fish (Pingree et al. 1974; Brown 1980). Pronounced fronts, such as those induced by strong tides are easily recognized by accumulation of debris, colour differences, and by differences in wave amplitude across them (Raymont 1980). Weak fronts are more difficult to identify but are still important biologically. Fournier et al. (1979) estimated that a front off Nova Scotia enhanced winter primary production by about 25 percent. Fournier et al. (1977) also found enhanced biological activity associated with the frontal region in May and August, and believed the underlying cause to be vertical transport of nutrients along the front.

Bailey (1957) first speculated that 'a renewal of surface waters through a very slow process of vertical mixing' could occur around the eddy at the entrance of Lancaster Sound. He did not elaborate about possible mechanisms.

Fissel et al. (1981) defined the intrusive current in Lancaster Sound in some detail and briefly discussed the presence of fronts associated with the current. Measurements in 1979 along an east-west transect through the center of Lancaster Sound identified an area (between Stations 7C and 6E), about 100 km in length, across which temperatures and salinities, and consequently densities, changed substantially in comparison to waters on either side of the region (Figs. 5.1.1 and 5.1.2). As indicated by the steeply inclined and sometimes vertical isopleths, density gradients are reduced within the front, and vertical movement of water could occur in this region more readily than in adjacent waters. Mixing of waters is strongly suggested by the presence of isolated pockets of warm water to depths of 75 m (Fig. 5.1.1). As shown in Figure 5.1.2, waters are disturbed at least to depths of 360 m.

The front identified in Lancaster Sound is not as well defined as that off Nova Scotia, where differences in surface temperatures and salinities are 5.5°C and 2.6°/oo over a distance of 25 km (Fournier et al. 1979). However, considering the more homogeneous nature of the waters in Lancaster Sound and northwest Baffin Bay (in contrast to those off Nova Scotia, which include the warm Gulf Stream), the front in Lancaster Sound is remarkably well defined. In addition, regions of reduced stability in the water column are not confined to the centre of Lancaster Sound but also occur near north Bylot Island and southeast Devon Island (Fissel et al. 1981). Such areas could occur all along the intrusive current and, as Bailey (1957) first theorized, could be regions of vertical transport of nutrients.

There is no direct biological evidence that the front in Lancaster Sound is responsible for the high standing crop of organisms in the area. Offshore biological research in the area in 1978 was designed to sample a large area (Sekerak et al. 1979), and the effort in 1979 was greatly reduced. Hence, sampling stations were not sufficiently close together, nor did they extend westward far enough into central Lancaster Sound, to address this question. Sekerak et al. (1976b) sampled a small number of stations in Lancaster Sound, but nutrients were not measured and sampling was not sufficient to document frontal effects.

The possible biological significance of a front (or fronts) in Lancaster Sound is profound. The front identified in the centre of Lancaster Sound between Admiralty Inlet and Croker Bay was at least 50 km wide and extended for unknown distances to the north and south. Although its dimensions and location very likely change with fluctuations of the intrusive current (it could even disappear at times), it would appear that even a slow replenishment of nutrients in such a large area during summer could greatly increase plant production. Of all the possible mechanisms discussed above, mixing of waters within the front appears to offer the greatest potential for enhanced production in Lancaster Sound, as opposed to most other arctic areas. It should be noted that similar conditions could occur in other regions with similar topographies and transport regimes, such as the eastern portions of Jones Sound and Hudson Strait.

On purely speculative grounds, if one assumed a front 50 km wide across Lancaster Sound (~90 km wide) and further assumed a slow rate of vertical transport (one m/day) of deep water containing 7.0 mg-at N/m^3 into the euphotic zone, then 2.8 million kg of nitrate could be made available to the

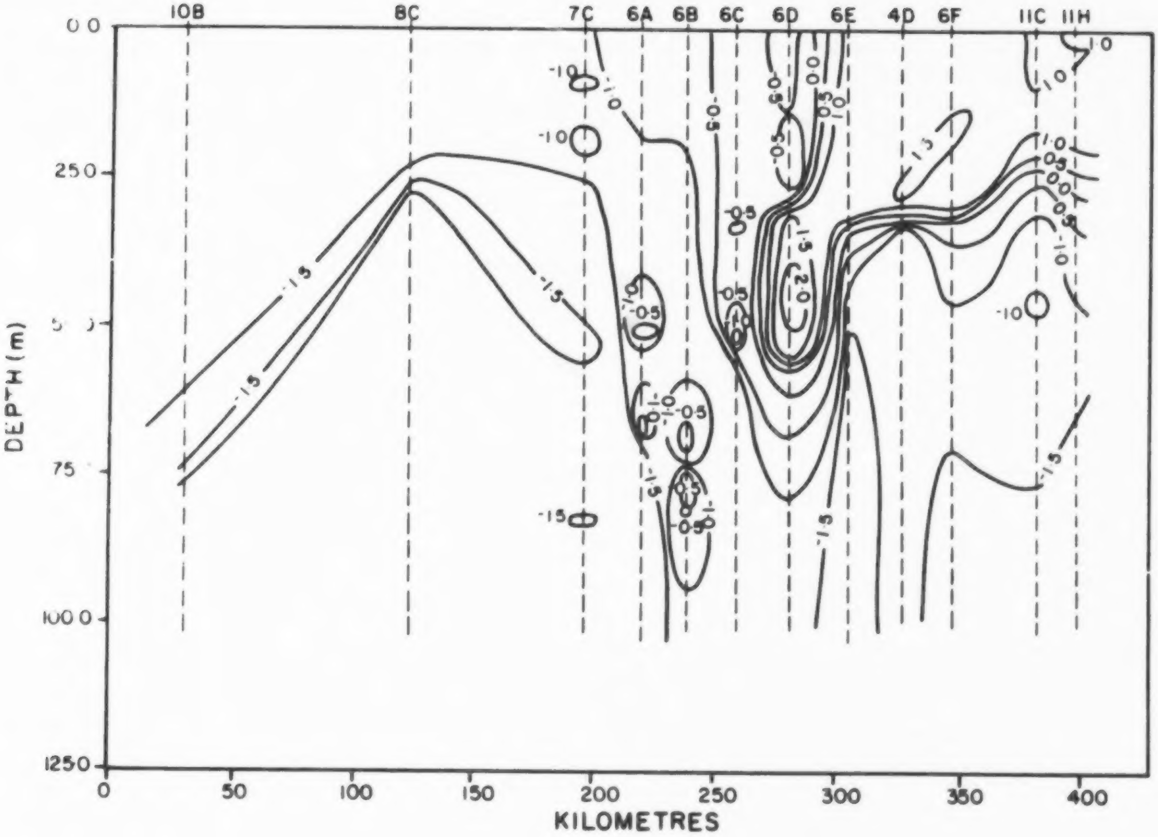

FIG. 5.1.1 Temperatures in shallow waters along an east-west transect in central Lancaster Sound, 23 August-5 September 1979. Courtesy of Arctic Sciences Ltd.

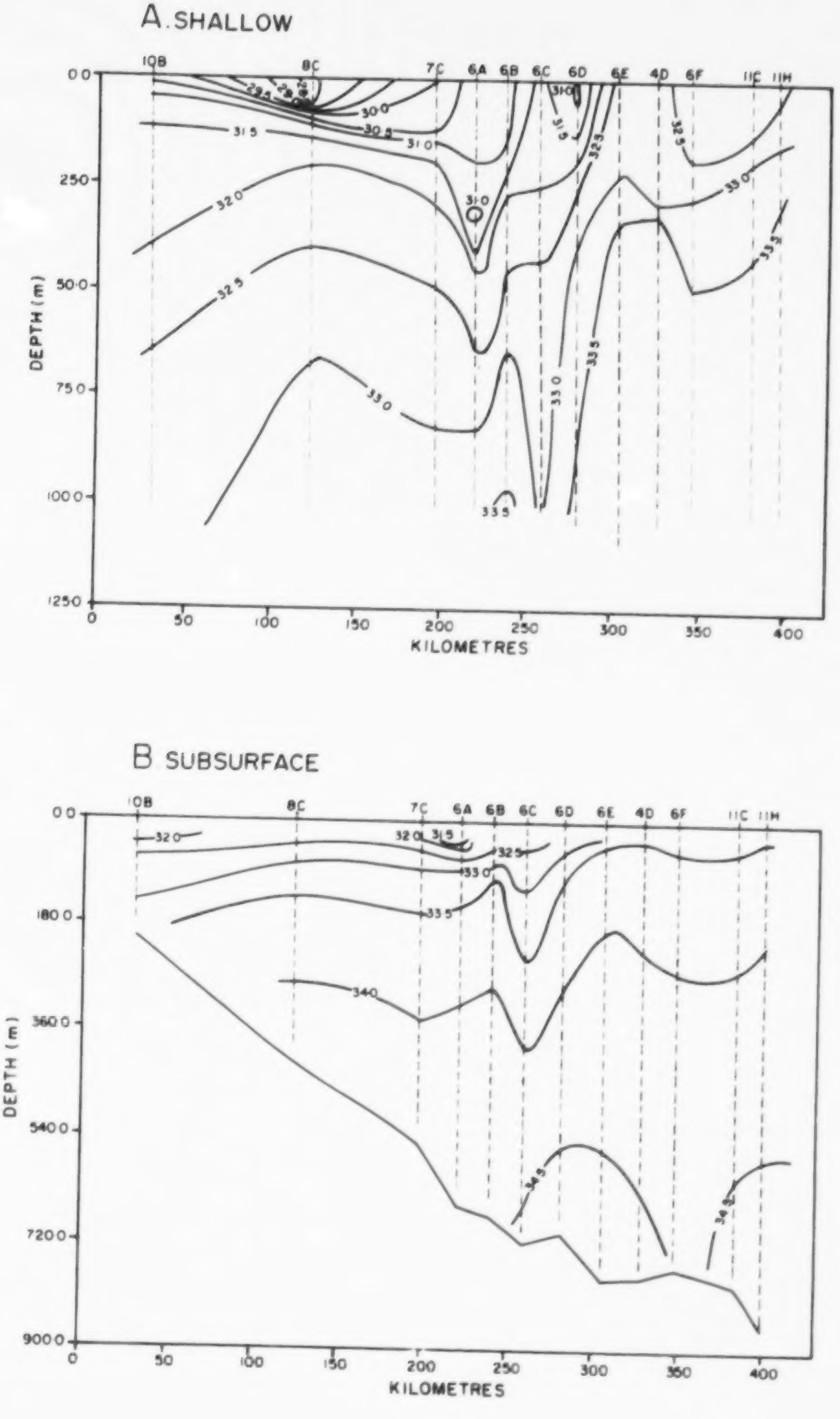

FIG. 5.1.2 Salinites in (A) shallow and (B) subsurface waters along an east-west transect in central Lancaster Sound, 23 August-5 September 1979. Courtesy of Arctic Sciences Ltd.

near-surface biological system over 90 days. This quantity is about 61 percent of the nitrate renewed in surface water during winter in the volume of Lancaster Sound (210 km x 90 km x 35 m) as previously discussed.

Additional data on transport of water in Lancaster Sound was provided by Arctic Sciences Ltd. (D. Lemon, pers. comm.). Rough approximations indicate that flows below depths of 300 m do not balance, in that inflow of water could be about 0.5 x 10^6 m^3/s more than outflow. Excess inflow must be removed at depths less than 300 m and vertical transport must, therefore, occur. Arctic Sciences assumed upward transport to occur in a band 150 km long by 30 km wide. The resulting vertical speed at a depth of 300 m in this area would be about 10 m/day. They noted that this speed would decrease with decreasing depth. D. Lemon (pers. comm.) emphasized that the above approximations are rough and could be in error by as much as 50 percent. However, data strongly suggest upward transport of large amounts of water in Lancaster Sound.

5.1.8 Guano

Evidence indicates that guano sometimes locally enriches nutrient concentrations in surface waters (Leentvaar 1967; Steven 1974). Steven (1974) estimated that 40,000 gannets at Bonaventure Island, Gulf of St. Lawrence, enriched surface water by nearly 2 mg N/m^2/day in an area of 100 km^2. Golovkin (1967) and Galkina (1977) reported that in laboratory experiments guano could significantly increase growth of phytoplankton. Bedard et al. (1980) concluded that 2500 to 12,500 seabirds in a 31 km^2 area of the Gulf of St. Lawrence contributed insignificant amounts of nutrients to marine waters. However, their study area was already rich in plant nutrients due to vertical mixing of water and moderately polluted freshwater runoff; this may have disguised any effects from guano input, since addition of nutrients to an already nutrient-rich medium is unlikely to have significant effects on productivity.

Nutrient concentrations in surface waters near the Cape Hay seabird colony on Bylot Island were measured in early September 1978 and described by Sekerak et al. (1979). Approximately 84,000 adult thick-billed murres were present earlier in the summer but only about 28,500 were present at the time of sampling (LGL Ltd., unpubl. data). Surface nitrate + nitrite concentrations were slightly greater in areas 'downstream' from the colony than in 'upstream' areas but differences were not statistically significant. Nitrate + nitrite decreased with increasing distance away from the colony and mean concentrations near the colony were slightly higher than at nearby oceanographic transects in early September. Again, however, these differences were not statistically significant. Concentrations of nitrate + nitrite $>$1.0 mg-at N/m^3 occurred about twice as frequently at the Cape Hay stations as at regular stations along transects. Thus, several trends suggest, but do not entirely confirm, that seabirds were adding detectable amounts of nitrogenous products to the sea near Cape Hay.

Perspective can be gained on the significance of nutrient recycling via seabirds if absolute quantities are considered and compared. Using the estimates presented in Table 4.5.8, about 1.7 million seabirds are present daily in the study area in summer, ignoring the millions of dovekies that remain in the area for a short length of time in May. Bedard et al. (1980)

found that four species of seabirds excreted an average of 27 mg-at N/bird/day with most of the nitrogen being in the form of ammonia. Over a 60-day period, seabirds in the Lancaster Sound area could thus produce about 2754 kg of readily utilizable nitrogenous products if all guano were deposited in the sea (which it is not). Even making that assumption, this amount of nitrogen is about 30 percent of the potential contribution from glaciers in a limited portion of the study area, but is only 0.06 percent of nitrate renewal during winter. Thus the overall effect on productivity must be insignificant, but local effects adjacent to major colonies such as that near Cape Hay might be detectable if studied intensively.

5.1.9 Summary

Table 5.1.1 summarizes the suspected contributions of the various nutrient renewal processes to primary production in Lancaster Sound. It is obvious that errors of even one or two orders of magnitude in assessing the potential contribution of nutrients from guano could not significantly affect a large part of the marine system in the study area. Errors of two orders of magnitude could increase the importance of nutrients in glacial runoff considerably, but we believe that our estimates have been liberal and have probably already overestimated the importance of this mechanism of nutrient enhancement. (This does not negate the possibilities that local benthic communities might benefit if nutrients are adsorbed onto glacial sediment which descends to the bottom, or that production in relatively small bays or inlets could be enhanced).

Fronts appear to have considerably more potential than either guano or glacial runoff to supply nutrients to the euphotic zone, although winter renewal of nutrients is the overall driving mechanism for annual primary production in the Arctic. The concept of fronts as operational forces in the enhancement of production in arctic areas has not previously been examined in detail. At this time, we do not know if our estimate of nutrient renewal within the front in Lancaster Sound is realistic. The assumption of upward movement of water at a rate of 1 m/day seems conservative in view of the much higher estimate of Arctic Sciences Ltd.

Another concept should be mentioned. It has been hypothesized that channels (such as eastern Lancaster Sound, Jones Sound and Hudson Strait) that discharge large amounts of relatively low salinity water into Baffin Bay and Davis Strait could act as estuaries and entrain deep, nutrient-rich water into the euphotic zone. It might appear that this hypothesis is largely nullified by the existence of the strong intrusive current and front in Lancaster Sound; there does not appear to be a 'smooth' outflow of water across most of Lancaster Sound. However, we now have at least some evidence of upward movement of deep water in Lancaster Sound, and of outflow at shallower depths. Mixing processes along relatively weak fronts are poorly understood and the complex and variable circulation patterns in Lancaster Sound further complicate identification of important mixing processes. Much of the above discussion is largely speculative, but present information indicates that frontal processes, or possibly a combination of frontal processes and estuarine-like entrainment, are the most likely mechanisms by which production in large portions of the study area could be significantly enhanced.

Table 5.1.1. Possible mechanisms of nutrient renewal in Lancaster Sound.

Mechanism	Limiting Nutrients Renewed	Area/Volume/ Population Considered	Kg-at N Supplied	% of Winter Renewal
Winter renewal	Nitrate	Small portion of study area (90 km x 210 km x 35 m)	4,600,000	-
Glacial runoff	Nitrate	10,300 km^2 of glaciers in Lancaster Sound	9300	0.2
Guano	Ammonia Nitrate	1.76 million sea-birds - all guano entering the sea	2754	0.06
Fronts	Nitrate	4500 km^2 front; 1 m vertical transport/ day over 90 days	2,800,000	61

5.2 Factors and Processes That Enhance Food Availability

Marine mammals and seabirds undertake long migrations to reach Lancaster Sound and western Baffin Bay, and to return to their wintering areas. While in their arctic summering areas these animals have to secure enough food for basic metabolic needs, to make up any energy deficits incurred during the northward migration, to provide for reproductive activities and in some cases to accumulate energy for the southward migration. The process of gathering food also requires energy and if the above requirements are to be met, the energy acquired from the collected food must be somewhat greater than the total energy expended to collect it. Therefore, any process that serves to concentrate food or make it more readily available will greatly enhance an area's attractiveness to these animals.

5.2.1 Zooplankton Patchiness and Vertical Movements

The distribution of zooplankton is patchy in the horizontal plane (Wiebe 1970) and variable but somewhat predictible in the vertical plane (Longhurst and Williams 1979). In the horizontal plane, Mackas and Boyd (1979) found that patchiness was extremely intense, that abundance contrasts of 4- to 5-fold were common, and that there was no characteristic patch size.

Some species of baleen whales appear to selectively feed in dense patches of zooplankton (Watkins and Schevill 1979). Brodie et al. (1978) have shown that to survive, a fin whale (Balaenoptera physalus) must feed on plankton patches with densities that are orders of magnitude greater than those found using conventional net hauls. Using sophisticated acoustic techniques, Brodie et al. (1978) found concentrations of euphausiids sufficient to fulfil the metabolic requirements of fin whales off Nova Scotia. The euphausiids formed discrete horizontal layers (Brodie et al. 1978) about 20 to 50 m in thickness (Sameoto 1980). Mean biomass of euphausiids in conventional net hauls was 0.1 g/m^3 (Sameoto 1971 in Brodie et al. 1978) vs. 9.2 to 11.90 g/m^3 in these layers (Sameoto 1980). The horizontal distribution of these layers was patchy (Sameoto 1976). Bowhead whales do not appear to be quite so dependent on very dense concentrations of zooplankton, but in the Beaufort Sea they too must feed in areas where zooplankton are somewhat concentrated (Griffiths and Buchanan 1982).

Acoustic investigations of the type done by Brodie et al. (1978) have not been carried out in the present study area. However, in the Arctic Ocean, Hansen et al. (1971) have documented the presence of a discrete scattering layer caused by the pteropod Limacina helicina. Limacina helicina is common in the study area and results of horizontal net tows indicate that it also occupies discrete horizontal layers here (Sekerak et al. 1976a).

Towards the end of summer, Limacina helicina may rise in the water column and form concentrations near the surface. In Brentford Bay, Boothia Peninsula, Thomson et al. (1978) found concentrations of 20 ± 6 (n = 3) indiv./m^3 at one m depth, and 1 ± 1 (n = 4) indiv./m^3 at depths of seven to 25 m. Late summer surfacing of this species has been observed in Eclipse Sound in 1980 (LGL unpubl. data), but was not documented during plankton sampling in 1976 (Sekerak et al. 1976a) or 1978 (Sekerak et al. 1979).

Parathemisto libellula also may rise to the surface, especially in late summer, and give the appearance of swarming (Dunbar 1946; Sekerak et al. 1976a). No direct evidence of this type of behaviour was obtained from plankton tows. However, dramatic late summer increases in the amount of Parathemisto found in fulmar stomachs from the south coast of Devon Island in 1976 (Bradstreet 1976) and in dovekie stomachs taken in Lancaster Sound in 1978 (Bradstreet 1979b) indicate that this phenomenon may occur elsewhere in in the study area, and may indeed be a common occurrence.

Young-of-the-year arctic cod occasionally may also concentrate at the surface in late summer. Thomson et al. (1978) observed large numbers of cod swimming at the surface in Brentford Bay in late summer. Plankton tows showed that they were concentrated at the surface and rare in the water below. This phenomenon appears to be unusual (Sekerak 1982).

The mechanisms causing zooplankton patchiness are under investigation (i.e., Sameoto 1976; Riley 1976; Longhurst 1981), but no widely acceptable model or theory is available.

Phytoplankton and zooplankton may be concentrated by Langmuir cells (Parsons et al. 1977; Evans and Taylor 1980). Under these conditions, zones of convergence may be visible on the surface as windrows of flotsam, and plankton may be concentrated below the surface in parallel bands. Convergence at tidal fronts has also been shown to concentrate plankton (Pingree et al. 1974). In the present study area, the complicated geography, surface circulation patterns, nearshore circulation patterns and density discontinuities caused by freshwater intrusion (Fissel et al. 1981) provide ideal conditions for the formation of tidal fronts. Surface slicks have been observed off the southeast coast of Devon Island, at the entrance to Pond Inlet and in other areas (LGL Ltd., unpubl. data). Feeding northern fulmars and black-legged kittiwakes have been observed to orient themselves along these slicks, and it is reasonable to assume that they are taking advantage of zooplankton that was concentrated by Langmuir cells and/or tidal fronts.

Plankton studies conducted in 1976 and 1978 were not designed to show the small scale distribution patterns of zooplankton. Multiple opening and closing plankton nets guided by echosounders, continuous plankton recorders, or the new generation of electronic 'in situ' plankton counters are required to document the quantity and quality of zooplankton patchiness. Vertical tows and unguided horizontal tows yield average concentrations of zooplankton but often do not sample the food organisms of marine birds and mammals adequately (Bradstreet 1976; Sekerak et al. 1976a; Finley and Gibb in press) and may not show concentrations of food large enough to sustain life at the higher trophic levels (e.g., Brodie et al. 1978; Griffiths and Buchanan 1982). However, the feeding habits of seabirds and marine mammals indicate that some zooplankters must form dense concentrations at some times and at some locations in the study area.

5.2.2 Benthos

As a food resource for vertebrates, the high arctic benthos can be divided into two major groups: littoral epibenthic animals (intertidal to three m depth) and the shallow water (to 50 m) benthos. In general, the former is heavily utilized by vertebrates while the latter appears to be underutilized.

Compared to temperate shorelines, the high arctic littoral is only sparsely populated; however several mechanisms exist to concentrate intertidal animals and make them more accessible to vertebrates. At low tide, intertidal amphipods are concentrated just below the waterline, whereas at high water they are spread out over the intertidal (Thomson and Cross 1980). On tide flats and gently sloping shorelines, these amphipods as well as planktonic organisms are often trapped by the receding tide and are accessible to shorebirds (Alliston et al. 1976). In the few places where intertidal algae are plentiful, they provide a damp refuge for animals that could not otherwise remain in the intertidal at low water (Thomson et al. 1978). Amphipods are more plentiful in the barren zone and have been observed to form very tight swarms (Thomson and Cross 1980). Some of these amphipods are active swimmers and are often found in the water column.

Mysids may form dense shoals in the barren zone. These shoals have been observed extending along several hundred metres of shoreline in Brentford Bay, under an ice foot in Bellot Strait where they were being preyed upon by arctic cod, in Eclipse Sound, and in Freemans Cove where ringed seals were feeding heavily upon them (Thomson et al. 1978, LGL Ltd. unpubl. data).

In almost all areas, biomass of the infauna below the barren zone is measured in the hundreds of grams and often in kilograms per square metre (see 2.6 Benthos), yet this abundant and easily accessible food resource is not heavily utilized in the study area. Bearded seals and walruses feed mainly on such organisms, but are not numerous and are sparsely distributed. White whales are more numerous and do feed on benthic animals, but the whales pass through the study area quite quickly. Eiders and oldsquaws, which are common in most shallow coastal areas, may be the main consumers of the benthic community.

5.2.3 Ice

The presence of ice enhances the availability of food to vertebrates in several ways. Fay (1974) summarized the various ways in which ice is of importance to pinnipeds. Factors which enhance food availability include: great **space** in which ice-adapted vertebrates can distribute themselves for feeding (and thus reduce local impacts on food resources); access to **food resources** (either ice-associated, and/or pelagic or benthic under ice-covered areas) from ice platforms; **transportation** by moving ice (pack ice) to new food sources; and the availability of **improved shelter** (relative to open sea conditions) in the favourable microclimatic conditions that are present in the lee of (or within) ice structures and ice types. Some of the more important habitats to vertebrates include the landfast ice surface, underice surface, ice edges, pack ice, icebergs, and glaciers. Below, the importance of these various habitats to vertebrates is discussed in the context of enhanced food availabilty.

5.2.3.1 Landfast Ice Surface

Landfast ice covers much of the eastern and central Canadian arctic during the winter months. Many ringed seals overwinter under this ice, through which they maintain breathing holes. The stable platform that landfast ice supplies allows ringed seals to exploit food resources over vast areas, regardless of whether these food resources are pelagic (hyperiid amphipods; epipelagic mysids, shrimps) or ice-associated (arctic cod, gammarid amphipods) (Dunbar 1941c, 1954; Vibe 1950; McLaren 1958; Smith 1973; Finley 1976; Lowry _et al_. 1977, 1978a, 1980). Adaptation to landfast ice (and pack ice) enables the ringed seal to be the most widely distributed and abundant marine mammal in the study area.

Polar bears feed primarily on ringed seals (Stirling _et al_. 1977a; Stirling and Latour 1978) and prefer to use landfast ice (Stirling _et al_. 1980). Use of landfast ice makes the food resources of the sea, through ringed seals, widely available to polar bears.

The ringed seal and polar bear are the only truly marine mammals capable of utilizing landfast ice (some arctic foxes move out onto the ice in winter). Other species are restricted to areas of unstable ice where open water is available for breathing and access to food, and additional ringed seals and polar bears use this habitat. Some marine bird species, primarily _Larus_ gulls, scavenge seal carcasses from polar bear kills on landfast ice, but this habitat is generally of little use to most seabirds.

5.2.3.2 Underice Surface

The undersurface of arctic sea ice supports a diverse assemblage and high concentration of microalgae comprised primarily of diatoms (Alexander 1974; Horner 1976, 1977; Dunbar and Acreman 1980; Cross 1982). In spring, the ice algae bloom occurs prior to the zooplankton bloom and provides not only a proportion of total annual productivity in the sea, but also forms the basis of a concentrated food source on a two-dimensional surface.

Various invertebrates including meiofauna (nematodes, polychaetes, and harpacticoid and cyclopoid copepods) and macrofauna (primarily gammarid amphipods) live on, or just within, the underice surface (e.g., Horner and Alexander 1972; Golikov and Averincev 1977; Cross 1982). A trophic link between the epontic flora and the ice-associated fauna has been postulated frequently (Apollonio 1961; English 1961; Alexander 1974; Horner 1977) and recently documented by Bradstreet and Cross (1982).

A small gadoid fish, the arctic cod (_Boreogadus saida_), occurs close to the undersurface of sea ice (Andriashev 1970; Wilimovsky in McRoy and Goering 1974; Golikov and Averincev 1977; Bradstreet 1982a; Craig and Haldorson 1981) where it feeds on ice-associated invertebrates and zooplankton (Bradstreet and Cross 1982). Arctic cod are a pivotal link in the transfer of energy from lower trophic levels to the higher vertebrates (see section 4).

The undersurface of the ice thus concentrates food items utilized by vertebrates (ice-associated invertebrates for cod, and cod and ice-associated invertebrates for marine birds and marine mammals) in a 'two-dimensional' habitat. Additionally, rough underice surfaces apparently shelter arctic cod from predators (Bradstreet 1980a).

5.2.3.3 Ice Edges

The ice-associated food resources under landfast ice are directly available to most higher vertebrates only at the edges of landfast ice. This leads to annually recurrent concentrations of many seabirds, notably murres, guillemots, fulmars, and gulls at ice edges (Johnson et al. 1976a; Nettleship and Gaston 1978; Bradstreet 1979a, 1982a; Divoky 1981; McLaren 1982). Narwhals and white whales concentrate at ice edges in spring, primarily because they act as barriers to further migration. However, narwhals, at least, feed on arctic cod while near ice edges (Finley and Gibb MS). It is not known whether such cod occur in association with the ice edge, per se.

As ice break-up proceeds, parallel bands of ice rot and break off from more solid ice. This process exposes previously unexploited, ice-associated prey to predators. Ice edges may, therefore, be a fairly dependable source of concentrated food during spring. Bradstreet (1977), using very conservative assumptions, estimated that murres alone removed 3.5×10^6 *Onisimus glacialis* (an ice-associated amphipod) and 1.5×10^6 arctic cod from along the ice edge between Griffith and Beechey islands (Barrow Strait) during a 35-day period in 1976.

In addition to providing access to ice-associated food, the ice edge provides better shelter from wind and waves than occurs in offshore waters (Bradstreet 1979a).

5.2.3.4 Pack Ice

Pack ice occurs in much of northern Baffin Bay during the winter months. Large numbers of ringed seals (several hundreds of thousands) and polar bears (~1700) occur on the pack ice during the winter, and in spring thousands of whales and hundreds of thousands of seabirds move through areas largely covered with pack ice. The presence of intermittent leads allows access to the underice fauna for many vertebrate species. The pack ice itself provides a haul out platform for walruses, ringed seals and bearded seals (Finley and Renaud 1980; Finley et al. in prep.). The southward movement of the pack ice may also transport ringed seals, bearded seals and walruses to new areas where previously unexploited pelagic and/or benthic food resources become available.

Millions of dovekies annually stage at the mouth of Lancaster Sound in May (Renaud et al. 1982). There, they eat pelagic crustaceans that are not known to be highly associated with the underice surface. Although such prey are widely available, dovekies avoid extensive areas of open water and areas near ice edges, preferring instead pack ice habitat (Renaud et al. 1982). Pack ice may provide good shelter for this small alcid in spring.

In the western Arctic and subarctic, the spring phytoplankton bloom occurs earlier at the ice front than in either open water or heavy ice back from the front (Alexander 1974; McRoy and Goering 1974). If this phenomenon occurs in the present study area, pack ice cover may increase local primary and secondary productivity. The underice surface of pack ice contains a somewhat different amphipod community than does the undersurface of landfast ice, and includes prey widely eaten by seabirds (Cross 1982). Such prey animals (e.g., *Apherusa glacialis*) could benefit from increased local primary productivity. Also, at the pack ice edge near Spitsbergen, wind-driven upwelling can occur (Buckley et al. 1979). No evidence of increased primary or secondary productivity associated with this upwelling is yet available, but such an increase is likely.

5.2.3.5 Icebergs

Icebergs that ground in areas where pack ice is in motion produce open water areas on their down-current side. These areas of open water are sometimes used by overwintering walruses and bearded seals (K.J. Finley, LGL Ltd., pers. comm.); icebergs can thus improve access to benthic feeding areas. Icebergs also provide resting sites for seabirds in extensive open water areas. Also, seabirds, particularly kittiwakes and fulmars, frequently feed at the bases of icebergs in open sea. This may occur because zooplankton are easily visible against the white surface of the underwater ice, or because there is entrainment of deep-water zooplankton along the underwater surfaces of icebergs (see Dunbar 1973), or both. Nutrient enrichment of waters adjacent to icebergs might also occur due to entrainment and/or runoff, although there is no evidence that this occurred near an iceberg studied in northern Baffin Bay (see Section 5.1.4 and Sekerak et al. 1979).

5.2.3.6 Glaciers

Runoff from glaciers contains elevated concentrations of nitrate (Sekerak et al. 1979), a nutrient required for phytoplankton growth. This nutrient enrichment may be caused by erosive action of the glacier on land (Apollonio 1973). Where glaciers enter deep water, high nutrient concentrations near the glacier faces may be caused by entrainment of deep water toward the surface (Dunbar 1973). Hartley and Fisher (1936) found that seabirds feed heavily on plankton near glacier faces. Koski and Davis (1979) noted a relationship between high bearded seal numbers and the locations of glacier faces in the eastern arctic, and suggested that this may be due to increased benthic productivity near glaciers.

5.3 Other Factors Affecting Vertebrate Distribution

The abundant food supply in the eastern Lancaster Sound-western Baffin Bay area, a consequence of the high productivity of the lower trophic levels, is a major cause of the high diversity and numbers of sea-associated birds and mammals in the area. However, several other factors may also influence the numbers, distribution and movements of these animals.

5.3.1 Accessibility to Food

As stated in Section 3.1, the pack ice in Baffin Bay breaks up earlier in the northwestern portions of the bay, including the study area, than in areas farther south. By late April or early May, there frequently are substantial amounts of open water, especially at the mouths of Lancaster Sound and Jones Sound. Leads along well developed fast ice edges are also present by this time. Consequently, large parts of the study area provide reliable staging and resting areas for early migrating animals.

The fast ice edges in the eastern Lancaster Sound-western Baffin Bay area are, with the exception of the edge across Lancaster Sound in 1978 and 1979, recurrent and dependable phenomena. The importance of these edges in May and June, as evidenced by the large numbers of seabirds along them, has been described in Sections 2.8, and 3.2. Their importance lies in the accessibility of an underice (epontic) community with associated herbivorous amphipods and arctic cod, both of which are food sources for seabirds. Bradstreet (1980a) concluded that fast ice edges were a major attraction to thick-billed murres in spring because of this food source, and suggested that the presence of dependable ice edges was important in determining the locations of murre nesting colonies.

Ice edges and leads may also serve to concentrate seabirds through a 'leading line' effect (cf. Geyr von Schweppenburg 1963), and marine mammals through a 'barrier to migration' effect. The leading line effect may sometimes also apply to marine mammals, and the barrier effect to seabirds. The barrier effect was very evident in 1978 and 1979 in eastern Lancaster Sound; large numbers of marine mammals (belugas, narwhals and harp seals) and seabirds were prevented from moving farther west to their traditional summering areas by a barrier of fast ice that remained unusually late in the season. Finley and Gibb (MS) believed that ice edges were not important feeding areas per se for narwhals, but rather that ice edges acted as barriers to movements into traditional summering areas. In 1976, when the spring ice edge was located far to the west in Barrow Strait, Bradstreet and Finley (1977) did not find any strong preference by marine mammals for ice edges although some seabirds were certainly attracted by the feeding opportunities there.

The occurrence of both extensive areas of close pack ice and extensive areas of open water in the present study area provides access by seabirds to two different types of food supply. Surface feeders such as northern fulmars and black-legged kittiwakes use offshore waters with little or no pan ice, whereas divers, such as murres, black guillemots and dovekies, use offshore areas with a high degree of pan ice cover (Section 3.2).

Similarly, varied coastal topography provides access to different benthic communities along the coasts of islands. Although landfast ice covers much of the coastal portions of the study area in spring, there are recurrent and generally dependable areas of open shallow coastlines. Examples of such include the coast between Cape Warrender and Cape Sherard, Raper Point and Belcher Point, all on Devon Island, and the south coast of Coburg Island. In these areas large numbers of common eiders, king eiders and oldsquaws congregate in May and June prior to moving inland to nesting areas (Section 2.8). The importance of shallow water areas to the eiders was demonstrated in 1978 when a shelf of fast ice covered the shallow waters off south Devon Island and forced large numbers of eiders to gather along Coburg Island instead. Many fewer eiders were observed migrating through Lancaster Sound in May-June 1978 than during the same perods in 1976 and 1979 (Section 2.8, McLaren and McLaren 1982). In August and September, glacier fronts along Devon and Ellesmere Islands provide access to an abundant food source to fulmars, kittiwakes, glaucous gulls, bearded seals and walruses (Sections 2.8, 2.9, 3.2, 3.3).

5.3.2 Availability of Nesting Areas

The very varied geology of the eastern Lancaster Sound-western Baffin Bay area provides suitable nesting sites for large numbers of birds that use the seas for either feeding or nesting. Large seabird colonies, totalling an estimated 425,000 pairs of fulmars, murres and kittiwakes, are located on cliff faces at Princess Charlotte Monument on Coburg Island, near Cape Hay and Cape Graham Moore on Bylot Island, and Buchan Gulf and Scott Inlet along eastern Baffin Island. Countless smaller colonies of glaucous gulls are widely distributed on rocky outcrops along the coast, and black guillemots nest on cliffs, either singly or in small colonies, from Coburg Island south to east Baffin Island. Other species utilize low-lying tundra regions in the study area. The world's largest greater snow goose colony is situated on southwest Bylot Island, and eiders, oldsquaws, loons, arctic terns and shorebirds nest in such habitat along the coasts of both Bylot and Devon islands. Although the presence of suitable nesting areas is not the only requirement for breeding in an area, the absence of such sites would markedly reduce both the diversity and the overall numbers of birds in the study area.

5.3.3 Migration Routes

The eastern Lancaster Sound-western Baffin Bay area is the gateway to Lancaster Sound and Jones Sound, the major migration corridors for waterbirds and marine mammals that summer in the central arctic. Sections 2.8 and 2.9 describe the species involved and the timing of both eastward and westward movements of these animals. Thus, in addition to the large numbers of birds and mammals that nest and summer in the study area, many others move through it in the spring and fall. In years when fast ice blocks entrance to the channels, these migrants must remain in the study area for periods longer than normal, awaiting break up of the ice.

6.0 ECOLOGICAL SIGNIFICANCE OF EASTERN LANCASTER SOUND AND BAFFIN BAY

The eastern Lancaster Sound-western Baffin Bay area is one of the most important regions in the Canadian Arctic. It supports a high diversity and large numbers of marine birds, mammals and lower life forms. In a national or international context, it ranks as a major staging and breeding area and migration corridor for seabirds and marine mammals. Several factors, many of which interact, make this region biologically important.

Ice conditions appear to severely limit the productivity and distribution of marine mammals and sea-associated birds in arctic regions. Sea ice conditions are so rigorous in the Arctic Ocean that marine mammals and sea-associated birds are largely excluded. However, ice conditions ameliorate from west to east through the arctic islands and are less severe in the Lancaster Sound-western Baffin Bay region. In the spring, the pack ice in Baffin Bay clears from northwest to southeast; this causes the northwest parts of the bay, including the study area, to be one of the earliest ice-free regions in the arctic. This area is one of the few reliable and recurrent ice-free areas in the arctic for early migrating birds and mammals. Annually recurring landfast ice edges, which are important feeding areas for fish, birds, and possibly some whales, are found along many of the coasts in the region during the spring. In addition, several coastal areas, especially along Devon Island, become free of ice in the early spring, providing important feeding and staging areas for animals that depend on access to benthic communities in shallow waters.

As the gateway to Lancaster Sound, this area is also the major migration route to the Canadian central high arctic for seabirds and marine mammals that reproduce and/or summer in the central arctic. In those years when Lancaster Sound is entirely ice-covered and thus unavailable as a migration route during the spring and early summer, the eastern Lancaster Sound-western Baffin Bay area becomes an important staging area for animals awaiting ice break-up in the sound.

The geography and physiography of the area provide a wide diversity of habitats that enables a similarly wide diversity of animals to occupy the area successfully. Coastal cliffs provide nesting habitat for several species of colonial seabirds, and low-lying coastal tundra provides nesting areas for several species of loons and waterfowl. Bays, fiords and channels remain ice-covered for much of the year, providing habitat for ringed seals and polar bears, but are free of ice in the summer, enabling whales to use them as summering areas. The presence of glacier fronts provides important feeding areas for certain seabirds and marine mammals in the late summer, when production in the area as a whole is no longer at a peak.

The following sections briefly review the significance of the various trophic levels to the ecosystem of the eastern Lancaster Sound-western Baffin Bay area.

6.1 Plankton and Fish

The vertical stability of the water column in most arctic areas prevents replenishment of nutrients that are required by phytoplankton for growth, hence leading to low primary productivity and low productivity of all trophic levels. Primary productivity appears to increase from the Beaufort Sea eastward through the arctic islands and reaches a maximum in Lancaster Sound. Upwelling caused by an intrusive current appears to replenish nutrients in the upper layers.

The arctic cod and amphipods, especially the hyperiid Parathemisto libellula, are of major importance in the transfer of energy from herbivores to higher-level consumers. Few seabirds or marine mammals (the bowhead being a principal exception) depend directly on herbivorous zooplankton.

6.2 Marine Birds

Large numbers of marine birds either migrate through or summer in the eastern Lancaster Sound-western Baffin area. Species that summer there travel to the area from wintering sites not only along west Greenland and the east coast of North America, but from as far away as the tropical Atlantic and even (in the case of the arctic tern) from subantarctic waters. Several of these species occur in numbers large enough to be of regional and national significance.

Northern fulmar.--An estimated 52,000 pairs of northern fulmars nest in the study area. An additional 152,000 pairs (estimated) nest in colonies to the west, and must migrate through the area to their nesting sites. Together, these birds represent about 70 percent of the estimated total breeding fulmar population in Canada. In addition, approximately 10,000 pairs of fulmars nest in northwest Greenland and may migrate through the area in spring. During the summer, uncounted thousands of fulmars, many of which are non-breeding subadults, are present both offshore and along coasts, ice edges, and (during August and September) glacier fronts.

Black-legged kittiwake.--The kittiwake colony at Coburg Island, estimated at 30,000 pairs, is believed to be the largest in eastern North America. Altogether, an estimated 53,000 pairs of kittiwakes nest in the eastern Lancaster Sound-western Baffin Bay area; an estimated 32,000 more pairs must migrate through the area to nesting sites in the central Canadian arctic. With the exception of 4,500 pairs at the entrance to Hudson Strait, the entire Canadian arctic population of kittiwakes uses the region; this represents about 46 percent of the eastern Canadian population.

Thick-billed murre.--Approximately 320,000 pairs of thick-billed murres nest in the eastern Lancaster Sound-western Baffin Bay area; another 86,000 pairs nest at the western end of Lancaster Sound and must migrate through the area. Including non-breeding birds, over 1,000,000 murres are present in the study area and Lancaster Sound during the breeding season, or about 33 percent of the total estimated Canadian arctic population. During August and September, adults and chicks from colonies in northwest Greenland may also move into the study area.

Dovekie.--Dovekies do not nest in Canada but enormous numbers migrate through the eastern Lancaster Sound--western Baffin Bay area in May en route to nesting sites in northwest Greenland. In May 1978 an estimated 14,000,000 birds were present in the area; this probably represents a substantial proportion of the total dovekie nesting population in northwest Greenland, although there are no recent estimates of its size.

Eiders.--The sizes of the Canadian Arctic populations of king and common eiders are unknown. However, it appears that the eastern Lancaster Sound-western Baffin Bay area is part of a major migration corridor for birds moving west to and east from summer feeding and nesting areas.

Snow goose.--An estimated 15,000-20,000 greater snow geese (1972 estimate) nest on lowland tundra along southwest Bylot Island, adjacent to Navy Board Inlet and Eclipse Sound. This is the largest aggregation of breeding greater snow geese, and may represent about 33 percent of the world's nesting population. In late August, many broods move with the adults to coastal waters near nesting areas.

6.3 Marine Mammals

Large numbers of marine mammals migrate through or reside in the eastern Lancaster Sound-western Baffin Bay area. Some winter in the area, or nearby off west Greenland or in Davis Strait, but others travel to the study area from as far away as Newfoundland. Several of the species occur in numbers large enough to have regional or national significance.

White whale.--Between 10,000 and 14,000 white whales migrate annually through the study area to summering areas in the central arctic. This total includes about 35 percent of the Canadian population.

Narwhal.--Over 80 percent of the North American population of narwhals migrate through or summer in the eastern Lancaster Sound-western Baffin Bay area. The population size of this species is not known accurately, but an estimated 20,000 animals were thought to have passed through eastern Lancaster Sound in 1976.

Bowhead whale.--The eastern arctic bowhead population is thought to number only a few hundred animals at most. The species is considered to be endangered. An unknown but large proportion of this population passes through or summers in the study area.

The diversity of habitats and high productivity of the eastern Lancaster Sound - western Baffin Bay area are affected in a unique assemblage of marine mammals and seabirds not found elsewhere in the North American arctic. The biota of the Lancaster Sound-western Baffin Bay region, on a smaller geographic scale, rival those of the Bering Sea. The abundance and diversity of organisms is more typical of the highly productive portions of the subarctic than of other high arctic areas.

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POOR

QUALITY

ORIGINAL